MAP WORK

PHYLLIS DINK

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PREFACE TO THE FIFTH EDITION

The present edition has been revised to bring it up to the requirements of the new syllabus in Map Work for the Intermediate Examination of the Panjab University. Portions not included in the Intermediate syllabus are marked with an asterisk : these sections have been retained either because of their interest and application or for the benefit of students preparing for other public examinations.

October, 1946

PREFACE TO THE FIRST EDITION

This small volume is intended for students of Geography, preparing for the Intermediate Examinations of Indian Universities, where the subject of Map Work has been receiving increased attention during recent years. Map work forms the laboratory of the geography student.

In compiling this book I have kept in view the limited knowledge of mathematics an average Intermediate student possesses. The syllabii of various Indian Universities vary ; portions not included in the Intermediate syllabus of the Panjab University are printed in small type.

Useful exercises, some of which are selected from University Intermediate Examination papers, are given at the end of each chapter.

I claim no originality in preparing this book and, therefore, deserve no eulogies that this book may earn. I acknowledge with gratitude the help I have received from books mentioned in the Bibliography.

March, 1938.

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ESSENTIALS

The student should provide himself with the following instruments and materials :—

1. A good pair of compass fitted with both pencil and pen points. The pencil point should be kept thin and round.
2. A drawing pen.
3. Pencils—two are necessary—H and HB
4. A pair of dividers.
5. Set squares and T-square.
6. Indian Ink.
7. India rubber
8. Protractor – A ' Service Protractor'' will be better.
9. Drawing copy book.
10. Graph paper.
11. Drawing box.
12. Ruling pen.
13. French curves.
14. Bevelled ruler.
17. Paint box or coloured crayons.

MEMORANDA

100 links =1 chain
10 chains =1 furlong
80 chains =1 mile

1 link =7·92 inches=8 in. (nearly).
1 chain =66 ft.=22 yds.
1 long chain=100 ft.

---

1 kilometre (km)=1,000 metres
1 metre =10 decimetres (dm)

1 metre =100 centimetres (cm).
1 centimetre =10 milimetres (mm).

---

1 fathom =6 ft.

1 nautical mile=1·1515 statute miles.

---

1 kilometre=1093·6 yards=0·621 miles.

1 metre=1·094 yards=39·371 inches.

---

12 inches =1 foot.
3 feet =1 yard.
5½ yards =1 pole, rod or perch.
4 poles =1 chain.

10 chains =1 furlong.
8 furlongs =1 mile (1,760 yards).
3 miles =1 league.

1,000 millibars =1 bar=29·53 inches of mercury.
1 in of mercury=33·86 millibars

Circumference of a circle $=2\pi r$
Area of a circle $=\pi r^2$

SYLLABUS IN MAP WORK FOR THE INTERMEDIATE EXAMINATION OF THE PANJAB UNIVERSITY

Paper (C) Map Work :

(*i*) Simple exercises on Plain Scales.

(*ii*) Representation of Direction.

(*iii*) Methods of showing Relief.

(*iv*) Interpretation of Topographical maps.
(Survey of India Sheets. Scale 1″=1 mile).
The use of Atlas Maps.

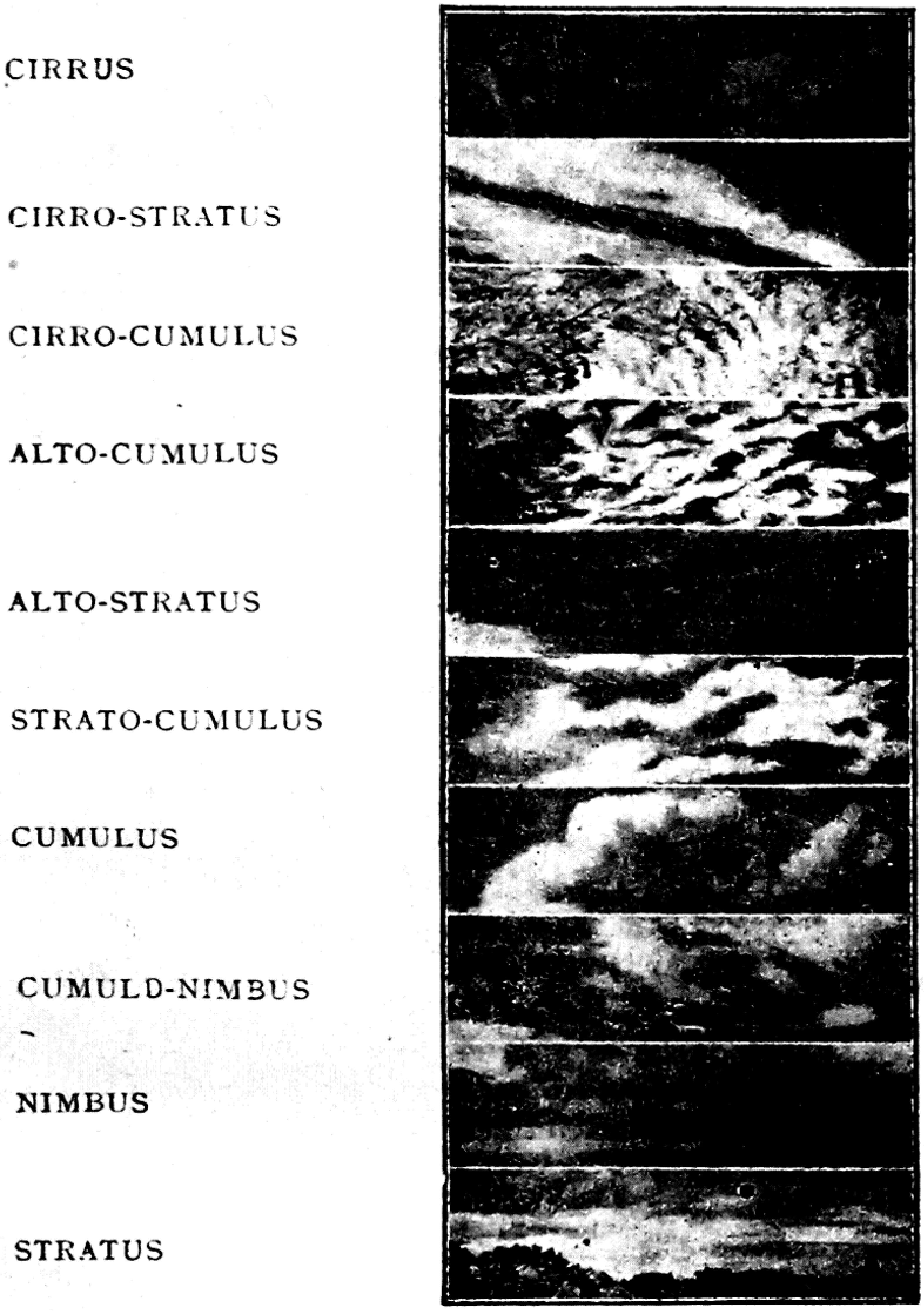
(*v*) Simple representation of climatic and economic data by
- (*a*) Line graphs.
- (*b*) Bar diagrams.
- (*c*) Circular diagrams.

(*vi*) Interpretation of Indian Daily Weather Report.

(*vii*) Merits, defects and construction by graphic methods of the following Projections : (Radius of the globe 1″ or 2″)
Cylindrical equal-area; Mercator's; Conical with one standard parallel ; Zenithal Equidistant (Polar Case).

Note :—Sections marked with an asterisk in this book are not included in the above syllabus.

CLOUD FORMS



[*Frontispiece*

MAP WORK

CHAPTER I

MAPS AND SCALES

1. **Maps.**—A map is a flat representation of a large or small area of ground. Maps give us a permanent record of the various features on the earth's surface. Their study is very important; they form the laboratory of the geographer.

A map may be regarded as a conventional picture of the earth's surface as seen from above, to which lettering is added for identification.

An aeroplane photograph gives us a true fascimile of the earth's surface on a small scale. A map, however, is different from an aeroplane photograph; in a map, we need to have a place for names; roads etc. are not true to scale.

A map, in other words, is some fraction of the true size of the area on the ground shown on the map; this fraction is known as the "scale" of the map. Thus, when we speak of the scale being 1 inch = 1 mile, we mean that two points one inch apart on the map are one mile apart on the ground. One mile is equal to 63,360 inches (1,760 × 3 × 12), hence we may speak of the scale as $\frac{1}{63360}$ which means that one inch on the map represents 63,360 inches on the ground.

The term **Map work** includes a study of the various types of maps, the methods and principles underlying their construction, and the various methods of showing landscape and the different phenomena an the earth's surface. Sometimes the term **Cartography** is used for the science of map construction.

In fact there are three aspects to our study; the land is measured by the surveyor, the measurements are collected and rendered on a map by the cartographer and the facts shown are interpreted by the geographer.

2. **Charts and Plans.**—The word 'chart' is derived from the French *carte* meaning a map and hence there is an overlapping between the words "map" and "chart". A chart is usually a record of the submerged portion of the earth's surface; thus steamship routes are shown on charts of various oceans.

The distinction between a map and a plan is a matter of convention. The word "plan" is usually used in connection with property surveys, *e.g.*, the plan of a building by an architect. The scale of a plan is usually greater than 6″ = 1 mile; while the scale of a map may be anything smaller than 6″ = 1 mile. These plans are sometimes known as *cadastral maps* from a French word *cadastre* meaning a detailed register of territorial property.

3. **Types of Maps.**—Maps may be classified into the following types, the object of classification being to show only certain features of the area mapped to avoid confusion:—

(1) An **outline map** shows only the coast-line of a country or a continent.

(2) A **political map** shows the political boundaries, provinces, towns, rivers and railways, etc.

(3) A **relief** or **physical** or **orographical map** shows the nature of the surface of the land; various colours may be used to distinguish high land from low land etc.

(4) A **bathymetric map** shows the varying depths of the ocean, *e.g.*, by using various shades of blue and indigo blue.

(5) A **bathy-orographical** map is a combination of Nos. 3 and 4 above.

(6) A **vegetation map** shows the distribution of natural vegetation.

(7) A **biological map** shows the distribution of vegetation, animals and races of mankind.

(8) An **ethnographical map** shows the distribution of races of mankind.

(9) A **climatic map** shows temperature, rainfall, pressure and wind systems for any particular season or as an average for a considerable number of years. In wall-atlases two sets of climate maps—one for summer or July and the other for winter or January—are usually prepared.

(10) A **weather map** shows the temperature, rainfall, pressure and wind systems for any particular day from data founded on observations made at various observatories.

(11) A **commercial** or **economic map** shows the centres of production of various commodities, direction of trade, density of population, etc.

(12) A **distributional** or **commodity map** shows the distribution of crops, animals, minerals or people in a given area by actual figures on a quantitative basis.

(13) A **geological map** shows the various types of rocks, their nature and age, inclination of the various beds of rock, soil, water-supply, etc., in relation to the upper parts of the earth's crust.

(14) A **topographical map** is a large scale map (usually less than 6″ = 1 mile) based upon actual survey of the land; it presents general information and shows details of both natural and man-made features.

(15) The **International map** is a survey map on a scale of 1 : 1,000,000 (1/M) as a result of the co-operation of various countries. It is divided into sheets, which are uniform in scale, size, conventional signs, and style of drawing.

Besides the above we have the **historical map** giving main facts of history of any country for any particular period; **astronomical charts** depicting the astronomical phenomena of the universe, *e.g.*, the motion of the planets round the sun; **charts** used for navigation; and maps used in art and in advertising.

4. **Scales and their Construction.**—If the distance between two stations is one mile on the ground, and these two stations are one inch apart on a map

the relationship that exists between these two distances will be called the scale of the map ; in this case one inch to one mile. A *scale* denotes the proportion which a length on a map or plan bears to the actual length on the ground. The representation of the distance on maps may be done in three different ways :—

(1) The Statement of the Scale.
(2) The Representative Fraction or Numerical Scale.
(3) The Plain or Linear Scale, also known as Graphic Scale.

5. The Statement of the Scale.—A statement of the scale is inserted on the map thus ;

10 ft. = 1″
1 mile = 1″
5″ = 1 mile

The scale is always appended on maps, so that the actual distance represented can be readily calculated.

Scales may be either small or large.

Small scales are scales of *miles to the inch*, *e.g.*,—

4 miles = 1″
64 miles = 1″

Atlas maps are on small scales.

Large scales are scales of *inches to the mile*, *e.g.*,

2″ = 1 mile
6″ = 1 mile.

Survey maps, Artillery and Trench maps are large scale maps.

6. The Representative Fraction.—In this case, the proportion existing between length on the plan and on the actual ground is indicated by a fraction whose numerator is 1. Such a fraction is called a "Representative Fraction" and is usually abbreviated to R.F. Thus :

$$\text{R.F.} = \frac{\text{Map distance}}{\text{Ground distance}}.$$

If a map has an $\text{R.F.} = \frac{1}{1{,}000}$ it indicates that any length on the map represents 1,000 times that length on the ground, whether it be inches, centimetres, feet or yards, etc.

Example 1. 1 inch to a mile = 1 inch to $1760 \times 3 \times 12$ inches
= 1 inch to 63,360 inches.

Hence $\text{R.F.} = \frac{1}{63{,}360}$

This scale is independent of units and is applicable to all countries.

7. Plain Scales.—Sometimes a line is drawn at the bottom of the map conveniently sub-divided, so that the reduced distances can be directly measured ;

such a device is known as a 'plain scale.' The following points must be borne in mind in constructing a scale :—

(1) The scale should be fairly long (usually about 6 inches) so that the longest measurement may be made directly from it.

(2) It must represent a convenient round number of the unit employed.

Example 2. *Construct a plain scale of 7 miles to the inch.*

As stated above a convenient length for a scale is usually about 6 inches.

A line 6 inches long will show $6\times7=42$ miles on the given scale. Let us take the nearest round number 40 miles to show the primary divisions and sub-divide it into 8 parts ; each part will show $=\frac{40}{8}=5$ miles. Add another 5 miles for the sub-divisions on the left of zero to show secondary divisions.

We have, therefore, to construct a scale to show $40+5=45$ miles in all, *i.e.*, both for primary and secondary divisions.

As 7 miles = 1 inch

$$\therefore\ 45 \text{ miles}=\frac{45}{7} \text{ inches}=6{\cdot}42 \text{ inches.}$$

We thus draw a line AB = 6·42 in. and sub-divide it into $8+1=9$ parts.

Take a line AB = 6·42 inches. From A draw AC a little longer than AB and making an angle of about 30° with AB. On AC, with dividers mark off nine points *a*, *b*, *c*.......*i* at equal distances, taking care that the last division mark is *approximately* below B. Join the last point *i* to B and from other points draw lines parallel to *i*B ; these lines cut AB and give the required divisions. Each division = 5 miles.

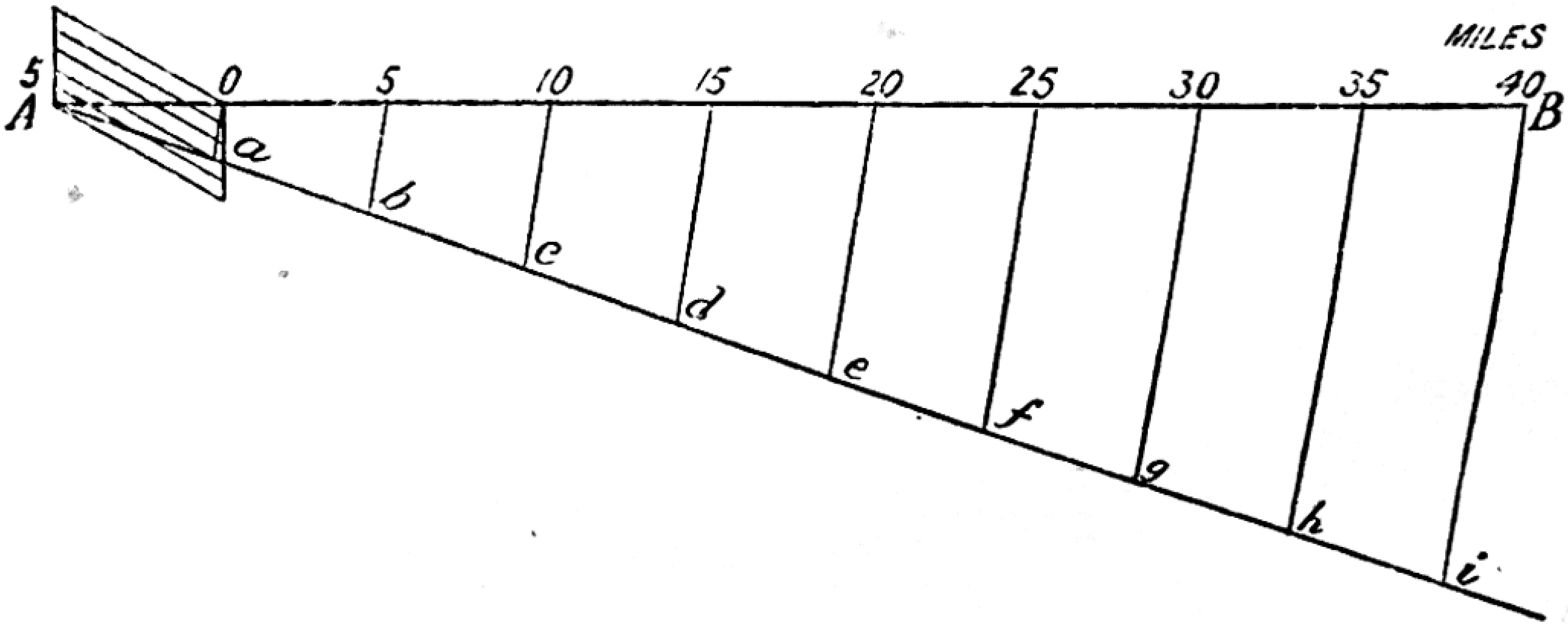


Fig . 1.

Beginning from the second, write the primary divisions thus :

0, 5, 10, 15, 20, 25, 30, 35, 40

Sub-divide the first division into 5 equal parts as shown in the diagram. Each of the smaller divisions = 1 mile. These are known as the secondary divisions.

Example 3. *Construct a plain scale to show yards on a scale of 4 inches to the mile.*

The scale given is : 4 inches = 1 mile = 1760 yards
∴ 6 inches will show $\frac{6}{4} \times 1760$ yards = 2640 yards.

Let us take a round number, say 2,500 for the primary divisions : if we subdivide it into 5 parts, each part will show 500 yards. Add another 500 yards for the secondary divisions. Thus the total length to be shown would be 2,500 + 500 = 3,000 yards. According to the given scale 1,760 yards = 4 inches.

$$\therefore \quad 3{,}000 \text{ yards} = \frac{3000 \times 4}{1760} \text{ inches} = 6{\cdot}81 \text{ inches.}$$

Draw a line 6·81 inches long and divide it into 5 + 1 = 6 parts as explained in Ex. 1. Each of the divisions would represent 500 yards.

Write the divisions thus on the scale :—

500 0 500 1,000 1,500 2,000 2,500 YARDS

Sub-divide the first division into five equal parts, each to show 100 yards.

The *plain scale* has the great advantage of remaining true after the map has been reproduced by photographic processes.

***8. Scale of Paces.**—In rapid field sketching it is sometimes impossible to measure distances with measuring instruments. To save time measurements are made by pacing. The length of an average pace is taken as 30 inches or 120 paces to 100 yards. Measure a length 100 yards on the ground and practice pacing over this distance.

A scale of paces is appended to the sketch, or paces are converted into yards or feet and a scale of yards or feet appended.

***9. Time Scale.**—A time scale is more convenient for touring, exploration etc. It shows distance travelled in a given time.

Example 4. *The scale of a map is $1'' = 4$ miles. Construct a scale of time for a party moving at 3 miles an hour.*

A line 6″ will represent 24 miles. This distance will be covered in $\frac{24}{3}$ = 8 hours.

Draw a line 6″ long and divide it into 8 parts. Each part will show the distance travelled in one hour.

***10. Diagonal Scale.**—An ordinary ruler is usually divided into tenths of an inch and cannot be used to measure a hundredth part of an inch. Such measurements can be got from a diagonal scale. The construction and use of a diagonal scale can be seen from Fig. 2 (*p.* 6) which reads to hundredths of an inch. Each of the diagonal lines progresses over one-tenth of an inch, so that each intersection with one of the parallel lines marks another hundredth of an inch.

Example 5. *To draw a diagonal scale to read yards, feet and inches on a scale of $1'' = 1$ yard.*

On graph paper (one inch square sides) draw a straight line AOB=4 or 5 inches, AO being one inch. Divide AO into 3 parts and join these points diagonally with similar divisions along A'O', the upper line of the square. Divide the vertical line AA' into twelve equal parts and draw lines from these points of division parallel to AO. The scale now reads yards, feet and inches on a scale of R.F. $=\frac{1}{36}$.

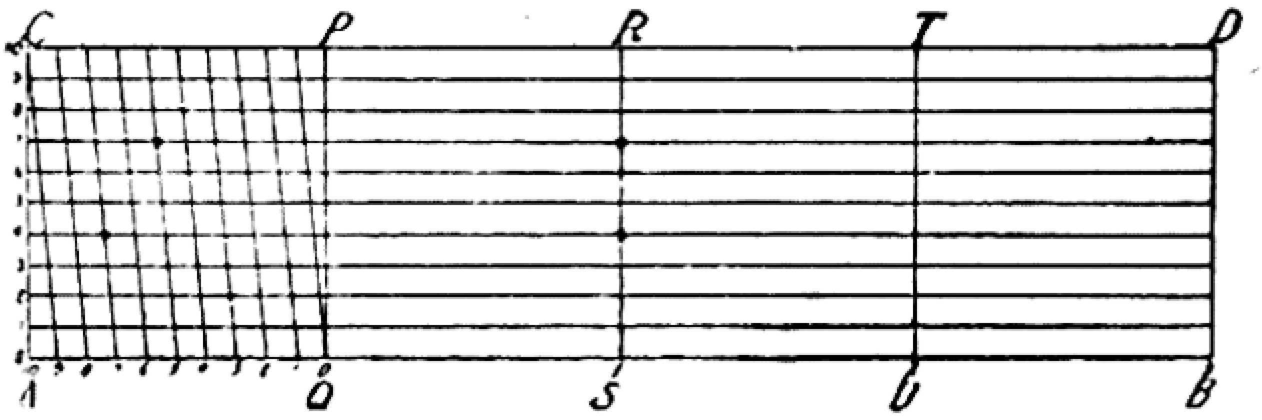


Fig. 2.

NOTE.—The left hand sub-division must be divided into the number of units of the second dimension required, and the number of parallel lines drawn above the scale line must be the same as the number of units there are of the third dimension in a unit of the second dimension.

***11. Change of Scale.**—A map may be drawn on a new scale, so that measurements on the new scale may be made directly. One of the simplest methods of enlargement or reduction is by squares.

Draw a set of squares on the original map, and prepare a similar set for the new map. The sides of the square in each case must be proportioned to the required representative fraction. Number both sets of squares to correspond, starting in each case from the top left-hand corner. Transfer the points where the features shown on the map cross these lines from one set of squares to the other.

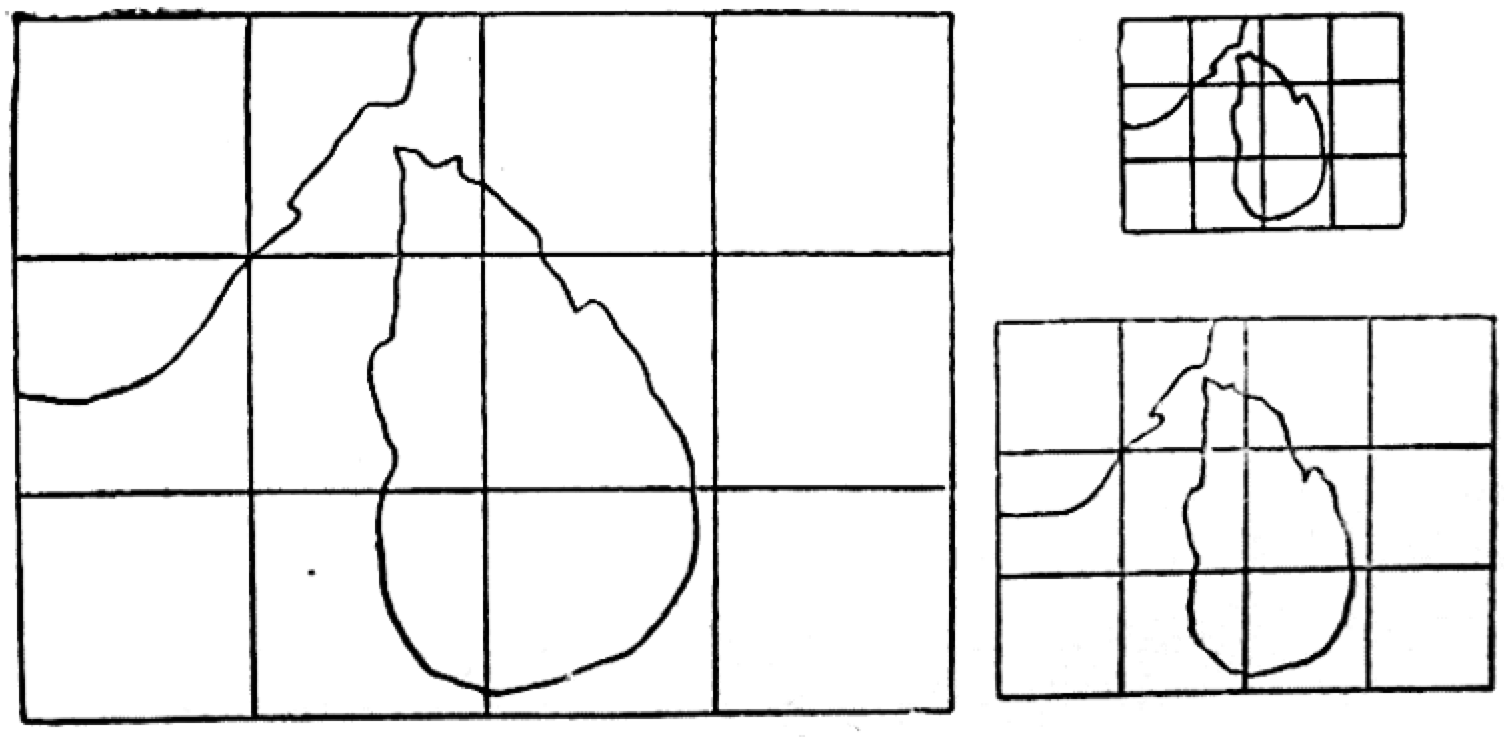


Fig. 3.

***12. Calculation of the scale from the length of one degree of latitude.**—If a map has no scale, its scale can be found as follows: **find the**

length of one degree of latitude in the centre of the map or on a straight meridian; this is approximately equal to 69 miles.

Example 6. *One degree of latitude on a map was found to be* $=1{\cdot}5$ *inches.*

$$\text{R.F.}=\frac{1{\cdot}5}{69\times63{,}360}=\frac{1}{2{,}914{,}560}$$

14. Measurement of Curved Lines.

—Use thread to measure the length of a river from your Atlas. Give a knot at one end of the thread. Place the knot at one end of the line and lay the thread bit by bit upon the curved line with your fore-fingers, taking care that the thread does not slide on the paper. When the other end of the line is reached, mark the point on the thread with pencil. Stretch the thread over the scale and read the length. Repeat and take the mean of two observations.

*13. Measurement of Area by Squared Paper.

—The squared paper is divided into square inches or square centimetres, which are further divided into 100 (or in the latter case into 25) smaller squares. Draw a map of your district on graph paper on a scale of 1″ = 1 mile. Find the area as follows: First count the complete big squares. Then count the small squares within the boundary; take fractions which are more than half within the boundary as complete squares, and neglect those which are less than half.

If the scale is 1″ = 1 mile, then 1 sq. inch = 1 sq. mile. But if the scale is 3″ = 1 mile, then $3\times3=9$ square inches = 1 sq. mile.

Again, if the scale is 5 miles = 1 inch, then $5\times5=25$ sq. miles are represented by 1 sq. inch.

EXERCISES

1. Convert the following scales to R.F.—
   (*a*) 6 inches to a mile, (*b*) 1 centimetre to 1 kilometre, (*c*) 1 inch to 200 links.
2. Construct a scale of 5 inches to 1 mile.
3. Construct a scale of $\frac{1}{50{,}000}$ to show miles.
4. Construct a scale of 100 paces to 1 inch [1 pace = 30 inches].
5. The R.F. of a map is given as $\frac{1}{400{,}000}$; how many miles are represented by one inch.
6. The R.F. of a map is given as $\frac{1}{100{,}000}$; how many inches represent one mile?
7. Construct a plain scale for 2 miles = 1 inch to show vards.
8. Draw suitable scales in (*a*) inches to the mile, (*b*) centimetres to the kilometre for the International Map whose R.F. $=\frac{1}{M}$.
9. Find the R.F. of the following scales :—
   5 miles = 1″ ; 5″ = 1 mile ;
   ½ cm. = 1 km. ; 2 cm. = 1 km.
10. Draw a map of your town or district on paper ruled in one-tenth inch square
(*a*) Reduce it to half the scale: (*b*) enlarge it to double the scale. (*c*) Calculate its area.
11. Construct a scale of 4 miles = 1″ to show half-miles.
12. Find the length of the Indus from your Atlas using a thread.

13. A motorist travelling at 50 miles an hour covers the distance between Lahore and Mughalpura in 6 minutes. If the distance on the map between Lahore and Mughalpura is 3", what is the R.F. of the map? Also construct a plain scale to show miles.

14. A map is to be made on horse-back to show a tract of country on a scale of 3 inches=1 mile. The horse trots at 6 miles per hour. Construct a suitable time scale for this purpose.

15. A dilapidated map has the scale torn off and missing. The distance between two places on the map as being 1·25 inches is measured to be =3½ miles. Construct a scale for the map.

16. (*a*) What do you understand by (1) map, (2) map projection, and (3) scale?

(*b*) The distance between London and Constantinople on a map drawn to a scale of 1 ; 12,000,000 is 8⅛ inches ; find the distance in miles and draw a plain scale.

(*Punjab, Univ., Inter, Sept. 1932 and 1933*)

17. What is a map? How does it differ from a picture or a diagram? Give a brief description of the various types of maps that you may have seen. (*Punjab, Univ., April, 1942*)

18. What is a scale? What is the respective use of a Plain Scale and Representative Fraction? What is the R.F. for a scale of 1 inch to 2 miles?

(*Punjab, Univ., Inter., Sept. 1942*)

*19. What is a diagonal scale? Explain its principle and draw a diagonal scale of 1 inch to 1 yard to read up to inches. (*Punjab, Univ., Inter., April, 1943*)

*20. Construct a diagonal scale for use with a 1/63,360 map to read up to hundredth parts of a mile and explain its geometry. (*Punjab Univ., Inter., Sept. 1943*)

21. Construct a scale of metres from a scale of 1 inch to one mile.

(*Punjab Univ., Inter., April, 1944*)

Outdoor Work

Tie a white tape to the front wheel of a bicycle. Find the number of revolutions the wheel makes in one mile (cycling straight).

Check your result. Measure the diameter of the wheel. Calculate the circumferrence ($=2\pi r$) and find the number of revolutions the wheel should make in 1 mile.

CHAPTER II

DIRECTION AND SUNDIALS

15. The Magnetic Compass.--Place a compass on the floor and turn it until the needle points to the north. Stretch a string along the north-south line of the compass and use it as a guide for drawing the N-S line. A line drawn at right angles to it will be East-West line.

Draw a circle with radius 2 inches. Draw 2 diameters at right angles and mark the cardinal points, N, E, S, W. Bisecting each right angle, mark N.E., S.E., S.W., N.W. Now mark 8 points named N.N.E., E.N.E., E.S.E., S.S.E., S.S.W., W.S.W., W.N.W., N.N.W.

16. True North.—The true North may be found by the following methods:

(1) *By means of the Pole Star.* For Northern Hemisphere: At night the direction of the true north can be found by the Pole Star. A constellation of seven stars known as 'the Great Bear' or 'Ursa Major' or Plough can be recognized by its shape like a soup-ladle. The two stars forming the side of the cup, known as the *pointers*, always point to the bright Pole Star. The Pole Star revolves round a point above the North Pole.

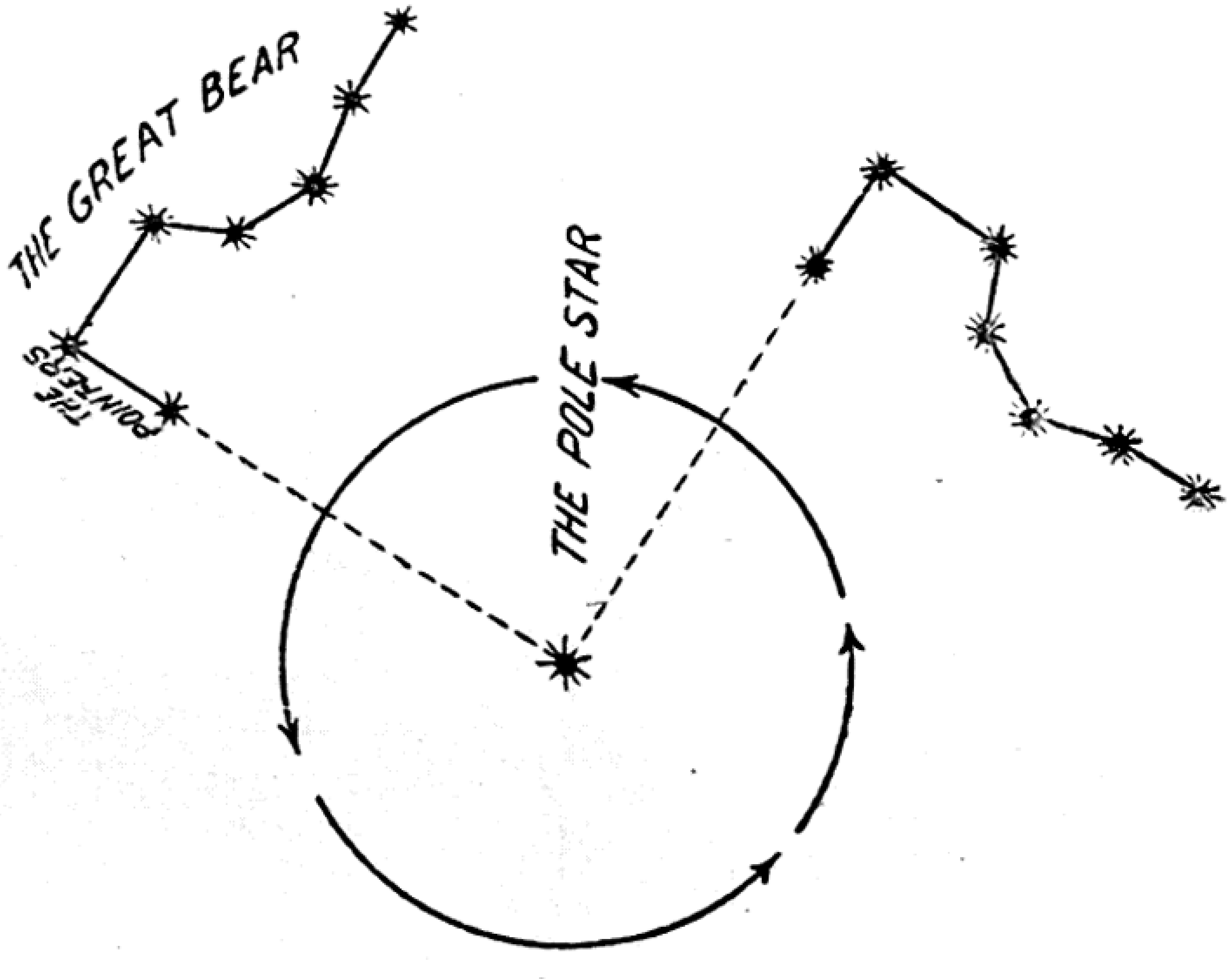


Fig. 4.

In the Southern Hemisphere the Southern Cross is used to find the direction. It is true South when its longest limb is vertical.

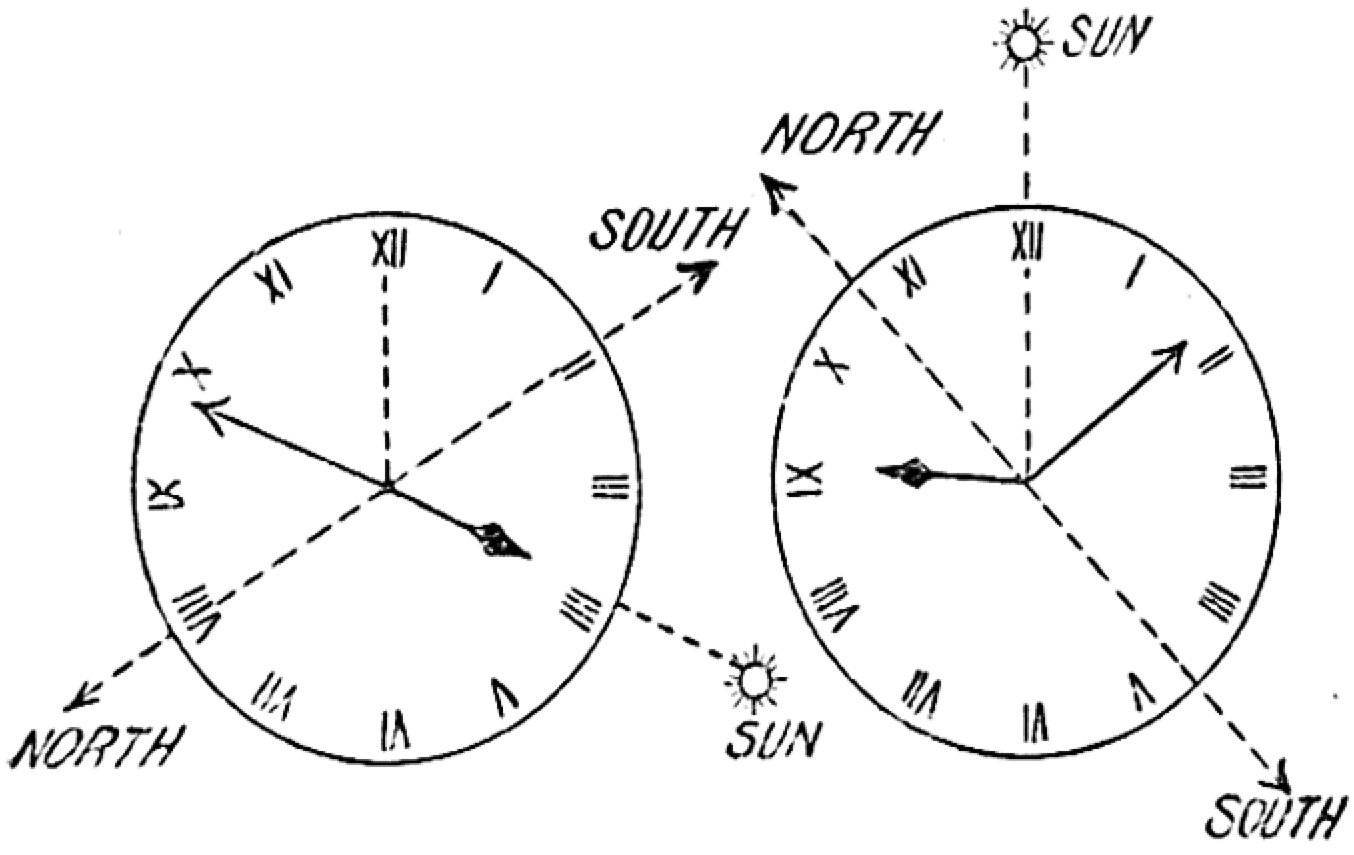
(2) *By means of the Sun.* Set up a stick vertically in the ground. At 12 noon its shadow will point away from the stick approximately due North.

The shortest shadow is always cast by the Sun when it is highest in the heavens. At the apparent noon the Sun is due south and the shadow points in a due northerly direction.

(3) *By a Watch.* This is a rough method and is based on the assumption that at noon by a watch showing local time the Sun is on the meridian.

(*i*) *For Northern Hemisphere.* Hold the watch in a horizontal position and turn it until the hour hand points to the Sun. Draw a line from the centre of the watch to 12 o'clock. The line bisecting the angle made by the hour hand and 12 o'clock points to South.

(*ii*) *For Southern Hemisphere.* Join the centre to 12 o'clock. Point this line at the Sun. Bisect the angle formed by this line and the hour hand; the bisector points to North.



(*a*) Fig. 5. (*b*)

Orienting or *Setting a map* means placing it in such a position that the north of the map points to true north.

The methods given above may be used for setting a map.

If the magnetic variation (see below) is known the map may be set with a compass.

Another method is to select two features which can be recognised on the map and on the ground. Place a ruler along a line joining them and turn the map until the selected objects on the ground are in the same line.

17. Magnetic North.—Take a magnetic compass. Pin a sheet of paper on a level table and stand a magnetic needle upon it. When the needle is steady, draw a line on the paper parallel to the direction of the needle. The line will indicate the magnetic North and South direction.

The compass will give a North line but it will not be true (Geographic) North. The compass needle does not point to the true North Pole. Hence we have, so to speak, two North Poles, *viz.*, 1, the Geographical (or True) North, and 2, the Magnetic North. The Magnetic North Pole is not a fixed point but is slowly moving its position from year to year. The angle between the Magnetic North and the Geographic North is called *Magnetic declination* or *variation of the compass.*

If the magnetic variation for a particular place at a particular time is known, the true North can be easily found.

Suppose the magnetic variation is 12°W. This means that the magnetic meridian is 12°W of the Geographical meridian. Draw a line cutting the magnetic meridian at an angle of 12° to the East. This line will be the Geographical meridian.

360

18. Bearings.—A *true bearing* is the angle which a line makes with the true North and South line measured from it, in a *clockwise* direction. A *magnetic bearing* is the angle which a line makes with the magnetic North and South line measured from it in a *clockwise* direction. To convert true bearings into magnetic bearings *add* the magnetic variation; to convert magnetic bearings into true bearings *subtract* the magnetic variation when the variation is West. When the variation is East, interchange the words *add* and *subtract.*

The following formula is useful in remembering the above:

True bearing ± Magnetic Variation = Magnetic Bearing.

The + sign to be used when the variation is West and the − sign to be used when the variation is East.

19. Shadow cast by the Sun.—Fix an upright rod where the Sun can shine upon it. Measure the length of the shadow of the stick several times. Observe that the length of the shadow decreases until mid-day and then increases until the Sun sets. In the afternoon, when the length of the shadow is the same as in the morning, mark its direction. Bisect the angle between the directions of the morning and afternoon shadows. This is a true north and south line. When the shadow is shortest it lies due north and south and this is when the Sun reaches its highest point in the sky for that day.

This incidentally gives us a method for finding the altitude of the Sun.

Example 7. A stick is 2 feet high; its shadow is 3 feet long. Make the drawing on a scale of 1 inch to 1 foot and measure the angular height of the Sun above the horizon in degrees.

* It is however not necessary to draw diagrams to scale to find the altitude of the Sun. In a right-angled triangle the ratio *perpendicular/base* is called the *tangent* of the angle. Thus if the stick is 5 feet and its shadow is 7 feet, the tangent of the Sun's altitude is $\frac{5}{7}$.

Example 8. To find the height of a tree or a building: fix a stick of known length vertically in the ground. Measure the length of its shadow; also the length of the shadow cast by the tree or building and calculate its height.

20. Sundial.—A Sundial is an instrument by which the time of the day is shown from the Sun's shadow thrown by an upright upon a flat surface. The upright that casts the shadow is called the gnomon. In the sundial the angle that the gnomon makes with the ground is the same as the latitude of the place. Place the sundial on a north-south line with the gnomon pointing northward. The gnomon is now parallel to the axis of the Earth, and the dial is parallel to the plane of the Equator.

21. The Equation of Time.—The apparent movement of the Sun across the sky is not uniform due to the varying velocity of the Earth on its orbit. There is thus a difference between the clock time (which has a constant scale throughout the year) and the sundial or apparent time. This difference is called the *equation of time.* This is expressed as:—

Clock Time = Sundial time ± difference.

When the sundial is slower than the clock, the equation of time is plus or has to be added, and when it is faster the equation is minus and has to be subtracted.

EXERCISES

1. Two birds fly from a certain tree. One flies 12 miles to the north-east and then 6 miles to the south, the other flies 8 miles to north-north west and then 10 miles south-south west. How far apart are they now?

2. An ice-bound ship drifts as follows:—
   8 miles N, 6 miles S.W., 7 miles S.E., 12 miles ENE, 14 miles SSW, 6 miles W. Map its course on a scale of 10 miles=1 inch.

3. Make a Sundial for any latitude from two circular pieces of cardboard and a knitting needle.

4. Explain the practical method of finding true north in the field. *(Punjab, Univ., Inter. April, 1943)*

5. What do you understand by (*a*) true bearing (*b*) magnetic bearing? State and explain the methods of finding the true North. *(Punjab, Univ., Inter. April, 1945)*

Out-door Work

Find the latitude of your college experimentally.

[Look at the Sun at noon. Find the number of degrees the Sun is from your zenith. This is called the "zenith distance" and is the latitude of your place.]

CHAPTER III

REPRESENTATION OF RELIEF

not equal

22. The uneven nature of the ground, known as its relief, is shown by indicating on the map the height and shape of various hill features. In order to be proficient in map-reading it is necessary to have a thorough knowledge of the various methods used to show these features.

The following methods are adopted for the representation of hill features :—

(1) Contours.
(2) Form-lines.
(3) Hachures.
(4) Hill-shading.
(5) Contours and Hachures.
(6) Contours and Hill-shading.
(7) Layer Tints.

These methods are not suitable for atlas maps because of their scale.

23. **Contours.**—A *contour* is defined as the representation on a map of an imaginary line joining all immediately adjacent points which are of the same height above mean sea-level and at given vertical interval apart.

If you walk along the side of a hill taking care neither to go up nor down, your path is a *contour line.*

Thus, a line on the map, joining all points at a height of 200 feet above sea-level, is called the 200-feet contour.

The vertical distance between any two successive contours is called the ***Vertical Interval,*** usually abbreviated as V.I. The vertical interval for any given map ordinarily is constant and is stated in feet. The contour lines are drawn at a given vertical interval apart. Thus, if the vertical interval of a map is 100 feet, the contours will be drawn at 100, 200, 300,......feet apart.

Two terms are frequently used in connection with contours: Vertical Interval and Horizontal Equivalent.

The *Vertical Interval* (written V. I.) is the difference in height between two successive contours. The V. I. is usually stated in *feet.* The V. I. is constant for any given map except in cases where many altitudes are shown, when the contours for the higher ground become very close together.

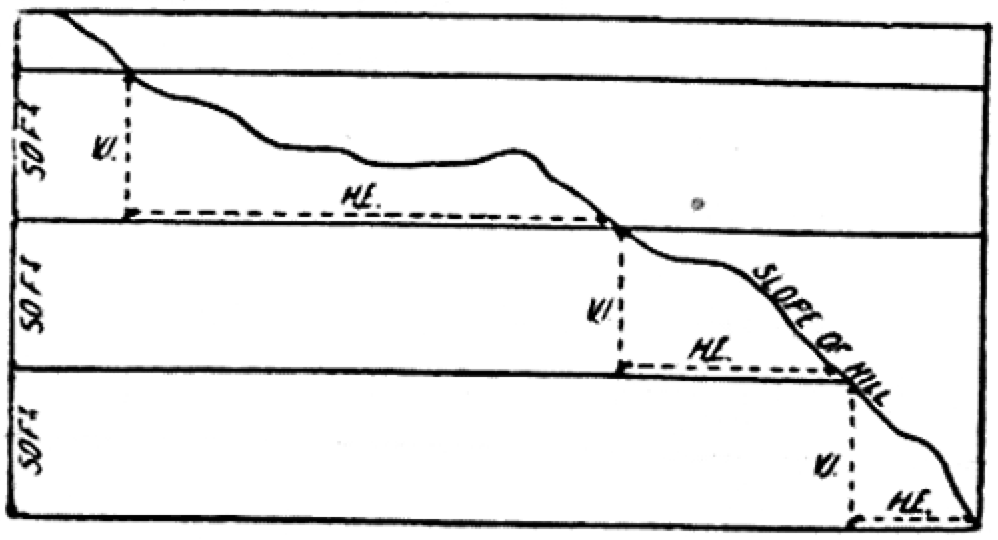


Fig. 6.

The *Horizontal Equivalent* (written H. E.) is the horizontal distance between two successive contour lines.

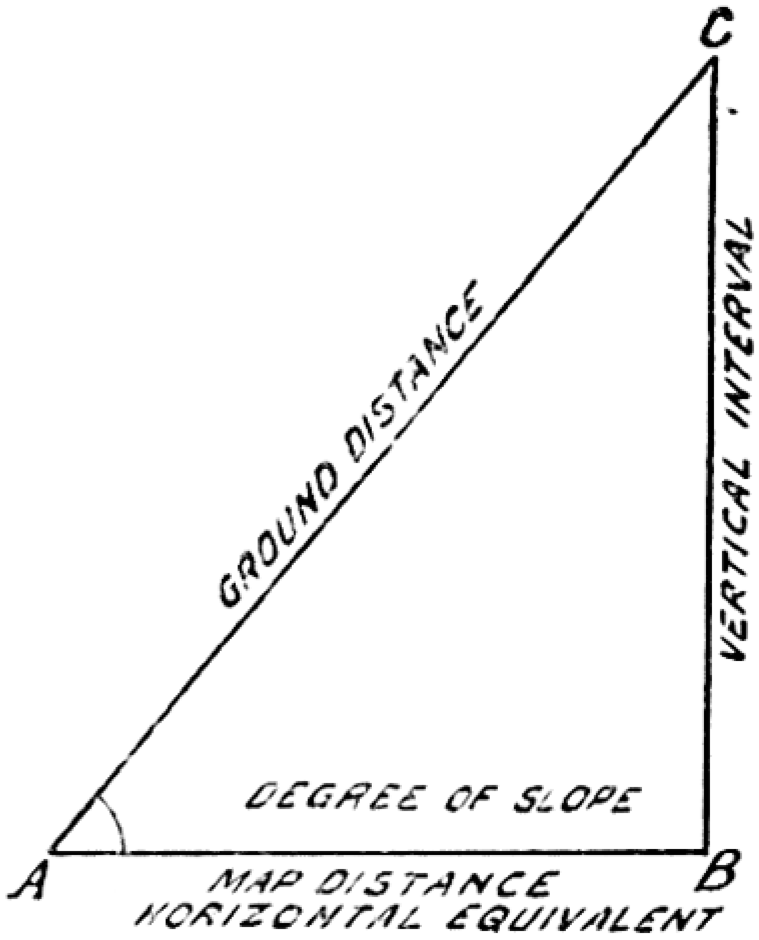


Fig. 7.

The H. E. is usually expressed in *yards*, and it varies all over the map. It is small for steep slopes, increasing in value as the slopes become gradual.

The Gradient between

$$A \text{ and } B = \frac{BC}{AB}.$$

If the ground were perfectly flat, *i.e.*, the gradient is nil, the distance AB on the map will correspond with the distance AC on the ground.

AB represents the distance on map between successive contours.

Experiment. Knock off the pipe of a glass-funnel and place it on a table with its wide mouth downward. Draw parallel lines round the funnel at intervals of half-an-inch. When looked from above, the lines will appear as concentric circles; when transferred to paper as they appear from above, these circles will be the contours.

Let us imagine an island with two hills one 300 feet and the other 200 feet above sea-level; the two hills are connected by a narrow part called the "Saddle," a little over 100 feet. If the level of water rose a hundred feet the island would be smaller but its shape would remain about the same. A further rise of water would cover the saddle and the two hills would be converted into two islands. A further rise of 100 feet would leave only one hill standing 100 feet above the level of water. The three coast-lines in position will give an idea of the contours of the island drawn at intervals of 100 feet.

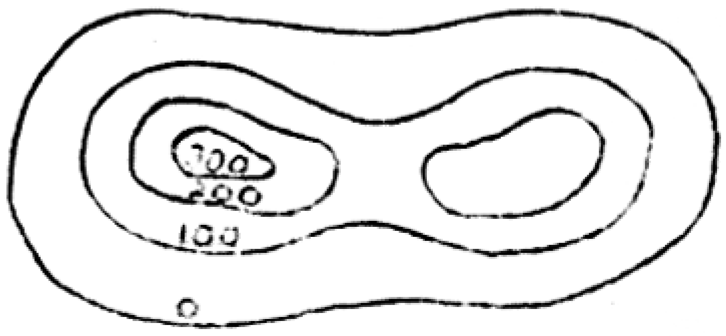


Fig. 8.

Consider a hill, whose one side is steeper than the other. A model made of plasticine, modelling clay or gelatine* would serve admirably for this purpose, Draw lines as in the above experiment. These lines when viewed from the top will appear close together on the steep side and wide apart on the gentle-slope side. See Fig. 9.

Hence—

When contour lines are close together, they show a steep slope but when they are some distance apart they show a gentle or more gradual slope.

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*Pour hot water over gelatine and let it set in a few hours. When firm it can be cut with a knife easily to the proper shape.

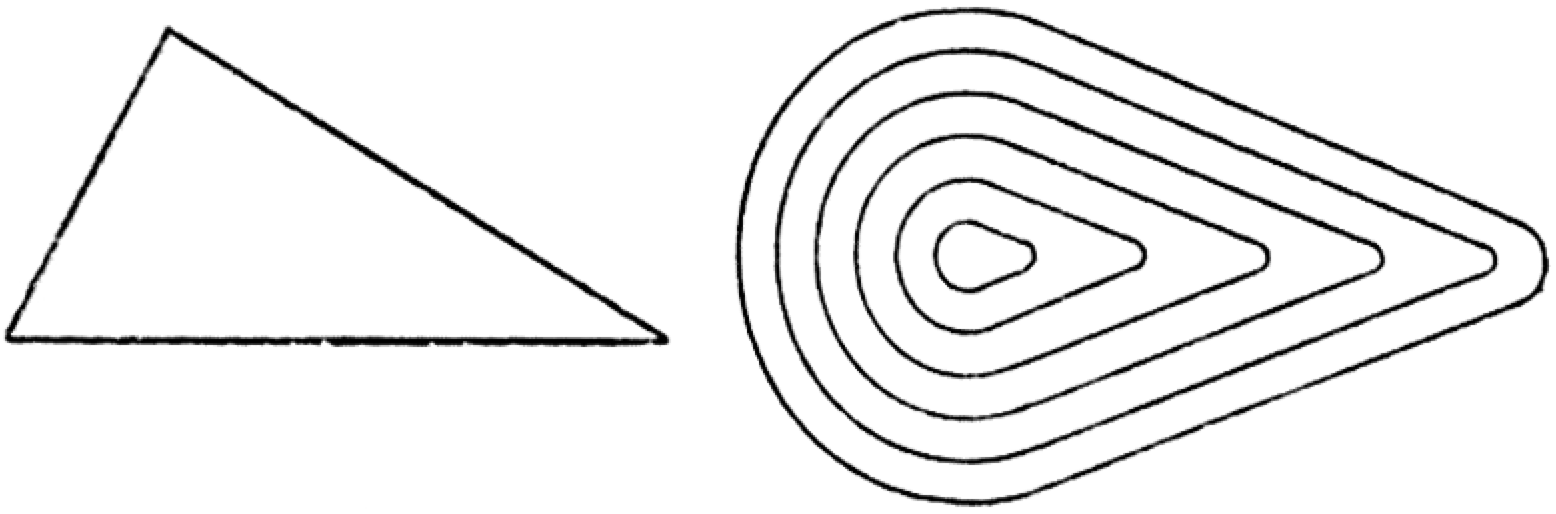
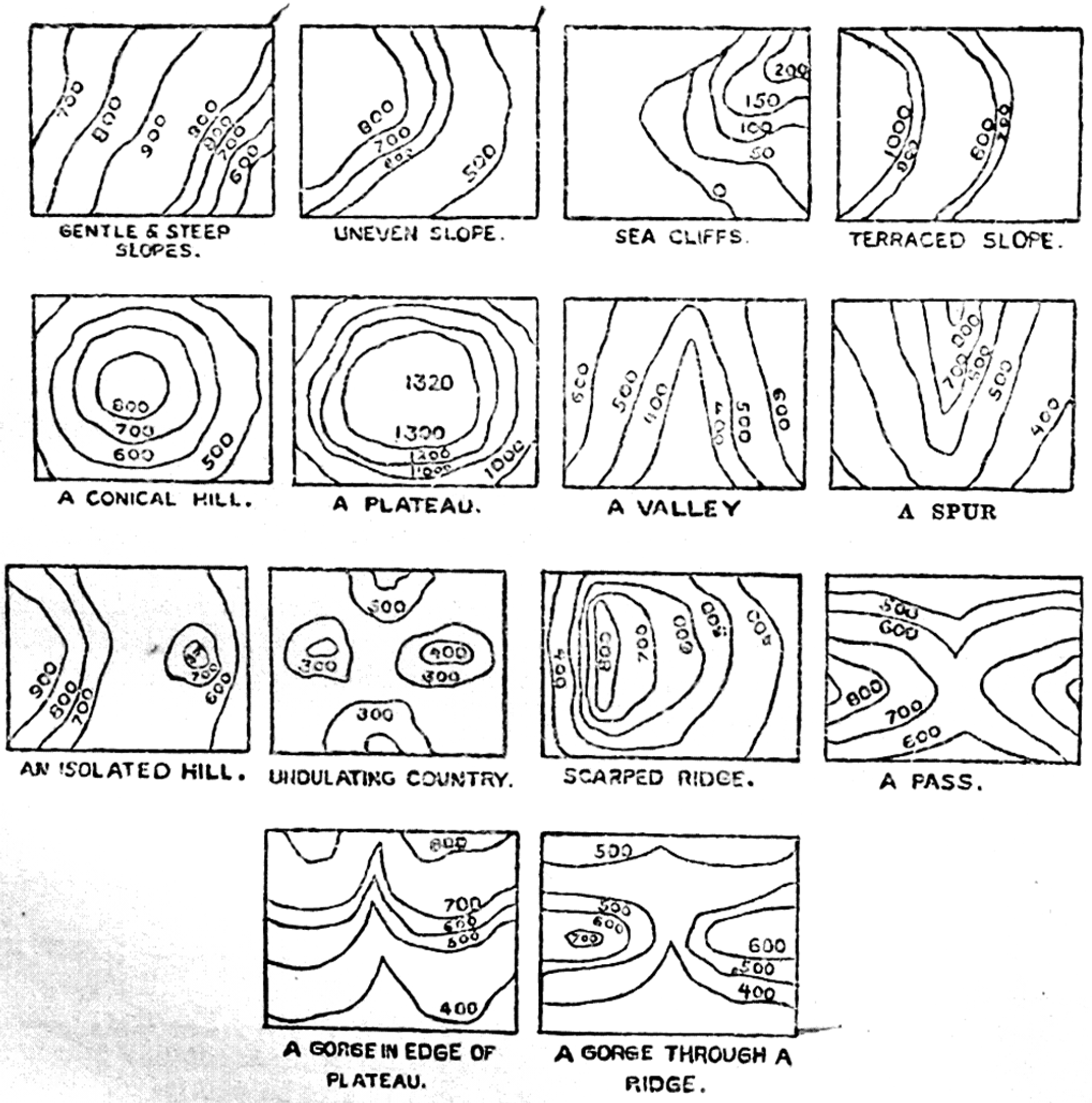


Fig. 9.

Hills and mountains do not have straight sides. It will be necessary to study a few irregular slopes as shown in Fig. 10. Study the various features and their contours carefully.



GENTLE & STEEP SLOPES.

UNEVEN SLOPE.

SEA CLIFFS.

TERRACED SLOPE.

A CONICAL HILL.

A PLATEAU.

A VALLEY

A SPUR

AN ISOLATED HILL.

UNDULATING COUNTRY.

SCARPED RIDGE.

A PASS.

A GORGE IN EDGE OF PLATEAU.

A GORGE THROUGH A RIDGE.

Fig. 10.

Note that the slope is

(*i*) *uniform* when the contours are spaced evenly.

(*ii*) *convex* when the space between the contours decreases towards the lower ground.

(*iii*) *concave* when the space between the contours increases towards the lower ground.

(*iv*) *undulating* when the above types are combined together.

24. **Points to be remembered in studying Contours.**—(1) Contours are close together on steep ground and are far apart on gently sloping ground.

(2) A small ring, with no contour inside it indicates a peak or a summit. A small triangle with a figure inside the ring denotes the actual summit.

(3) The contours both of isolated peaks and of lakes surrounded by higher ground on all sides are concentric curves, the difference being that in the case of peaks, heights increase towards the centre, while in the case of lakes, they decrease towards the centre.

(4) Both valleys and spurs are represented by V-shaped contours, the difference being that in the case of a valley the angles of the V's point towards the higher ground, but in the case of a spur they point towards the lower ground.

The angles are close together in steep valleys and wide apart in gently sloping valleys.

(5) Rivers flow only in valleys, connecting the angles of the V's.

(6) Contour lines must be drawn as continuous and not broken lines. They should be differentiated from other lines on the map by using a coloured ink usually red or brown. When there is a large number of contour lines, it is useful to mark every 5th or 10th line slightly thicker than the others.

(7) This is the most important point to remember. *Show the figures on that side of the contour line on which the ground is rising, i.e.*, the figures must always be above the contour line *as regards slope*, even though this may involve some figures being upside down when the map is viewed with the north at the top.

(8) Figures should be shown in continuous lines from top to bottom and must not be scattered about.

25. **Valley Contours.**—A valley is a depression or low-lying tract of land between two hills or mountains and often traversed by a stream or a river, which carries off the drainage of the higher ground.

The contours of a valley are marked by V-shaped contours. Note that the points of the V point to the high land.

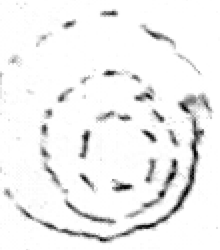
The points of V's mark the lowest part of the valley, hence rivers must cross the contours at the points of V's.

The contours are paired on opposite sides of the river. No river can run between two contours of different heights, *i.e.*, if the nearest contour on one side of the river is 400 feet, the one on the other side will also be 400 feet.

Ordinarily rivers rise at or near the heads of their valleys, unless otherwise stated.

Rivers on level land meander a good deal.

NOTE.—A **Spur** (or **Salient**) is a tongue of high land protruding from a mountain towards the low land. The spur is also marked by V-shaped contours, but in the case of a spur the points of V's point towards low ground.



26. Form-lines.—On small-scale maps, the heights are sometimes represented by form-lines. They are approximate contours, not figured. They show the general pattern of the ground and not the actual heights. These lines are broken.

[NOTE.—Broken and dotted lines are also used for boundaries, paths, etc., but in that case the spacing is uniform, *i.e.*, the space between the lines is equal to the lines themselves but in form-lines the spacing is not uniform.]

Sometimes numbers may be inserted to show the heights of peaks and summits, etc.

27. Spot-heights.—A spot-height shows the exact height of a point above sea-level.

Fig. 11 shows heights of several points. Draw contour lines from 200 feet upwards at intervals of 100 feet. Note that the 400 feet line will pass

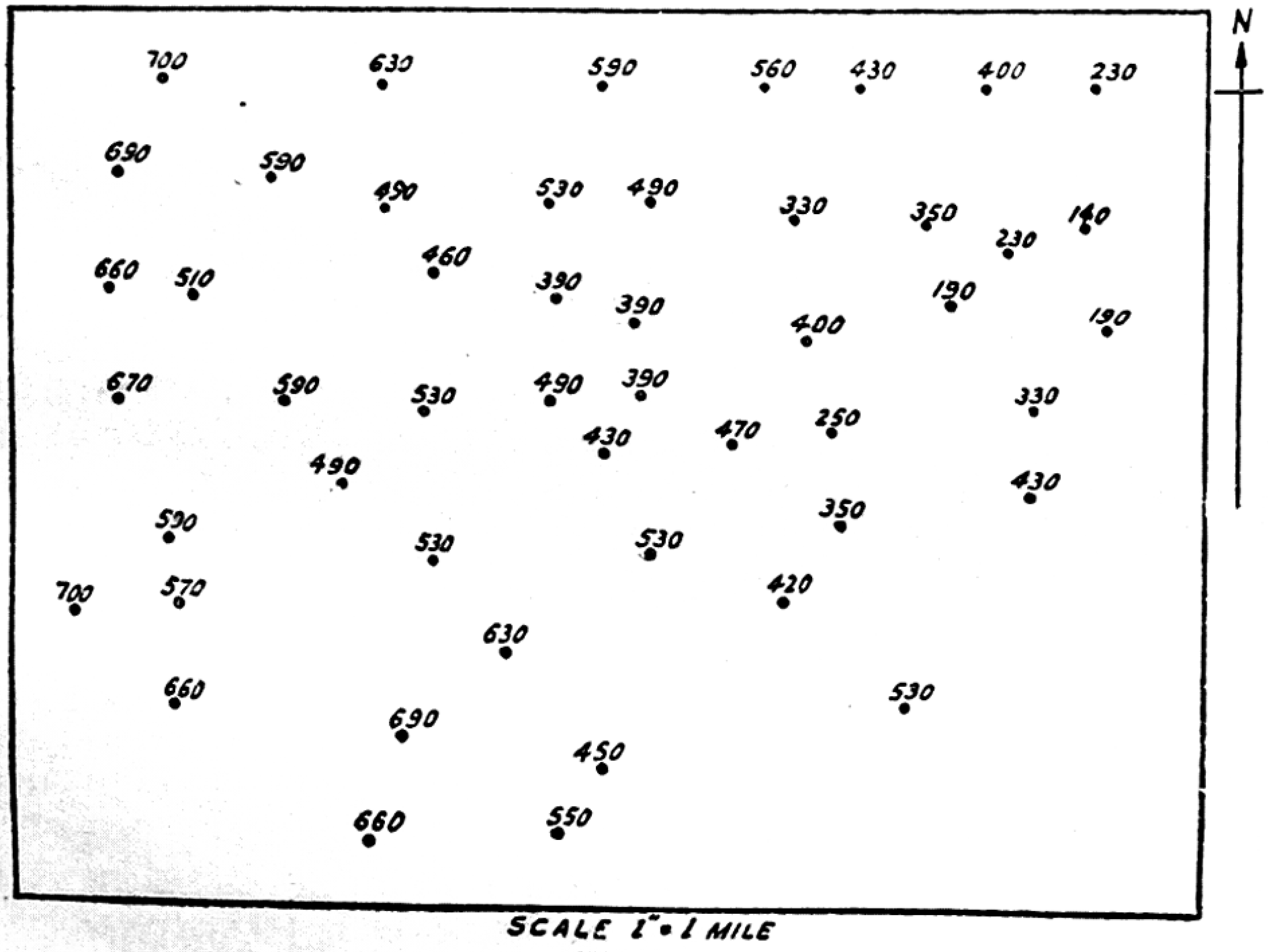


Fig. 11.

midway between points marked 350 and 450, but it will pass through a point which is nearly one-third of the distance from a point marked 370 to a point marked 470.

Having drawn the contours describe the land surface represented.

28. **Hachures.**—Hachures are short, disconnected lines, drawn down the slopes, in the direction of the steepest gradient. When the slope is steep, they are made heavy and close together; when the slope is gentle, they are made lighter and farther apart. Flat ground is left unshaded.

Hachures are drawn in the *direction* of the slope; thus they represent the direction in which water would flow over the surface if allowed to run freely. They are drawn at right angles to the direction of the contours at any point.

The *advantages* of hachured maps are :—

(1) They convey at a glance a general idea of relative steepness.

(2) In a contoured map when the vertical interval is large. the addition of hachures is valuable in showing minor features, which ordinarily are not shown by contours.

Their chief *drawback* is that they obscure other details and interfere with the legibility of the lettering on the map. This defect is now obviated by doing the hachures in colour.

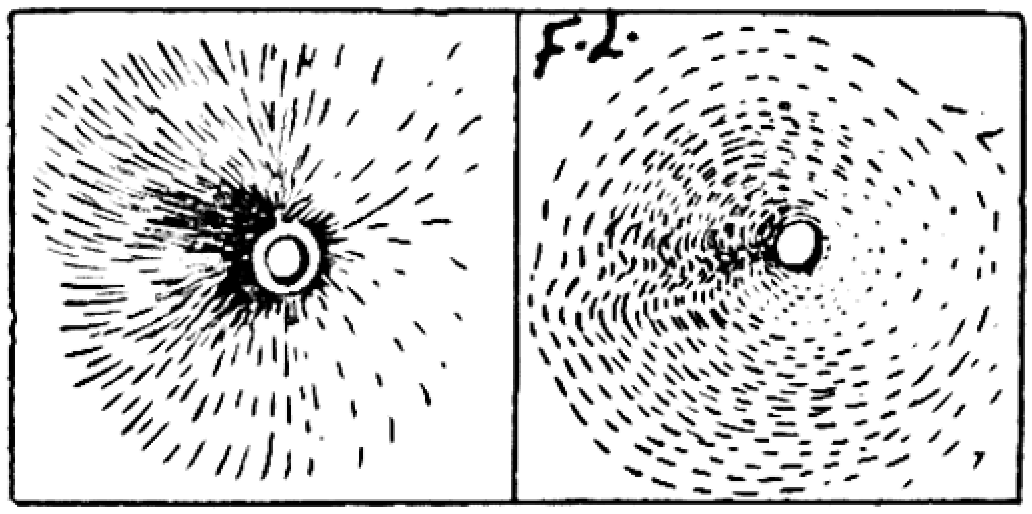


Fig. 12.

In Fig. 12. form-lines are shown on the right and hachures on the left for a hill whose right-hand slope is gentle and the left-hand slope is steep.

29. **Hill-Shading.**—In hill-shading the same effect as that in hachures is produced by a smooth graduated wash of colour or by pencil shading. This may be best explained by imagining that a light *vertically* over the country causes illumination which decreases in intensity the steeper the slope. Both sides of a hill, therefore, would be dark, and the summit and the valleys would be left white on the map.

In *oblique* hachuring or hill-shading, the shade is made darker on the sides of the slopes facing away from north-west. The effect produced is very much like the shadow cast by a light, ~~situated~~ in the north-west, falling obliquely on a relief model.

Hachures and hill-shading do not show exact heights, nor adequately the relative altitudes and the gradients. These methods are used for small-scale maps on which contours cannot be shown. Study a 16 miles = 1" map of any hilly country.

30. **Contours and Hachures.**—When the vertical interval of contours is a large one, contours are supplemented by hachures lightly shown in brown, which show the minor formations omitted by contours.

31. Contours and Hill-shading.—Contours are sometimes supplemented by hill-shading. This method is adopted by the French 1/50,000 maps.

32. Layer Tints.—Layers or tints of colour are used to denote all the land between any two named contours.

Blue is used for the sea, the shade increasing in strength in the following order as the depth increases:—

Very light blue
Light blue
Blue
Dark blue
Indigo.

Low-lying land is shown by the following colours in increasing order of the height of land:—

Green (usually dull-green)
Light-green
Yellowish-green

Highland is shown by the following shades of colour in increasing order of the height:—

Light brown
Brown
Dark brown
Reddish brown
Crimson red

High glaciated areas are shown in white—usually with a tinge of blue.

This method is growing increasingly popular, as a vivid picture of the distribution of high and low ground can be seen at a glance. There is, however, one objection, that when there is a considerable range in altitude, each change of colour interval cannot be distinctly shown.

NOTE 1.—If crayons are used, colouring should be done after all other detail have been inserted; with water-colour, the colouring should be done before filling in the other detail.

NOTE 2.—A map is usually judged by its appearance. Colouring must be done very carefully. It must be smooth and without any spots or patches.

33. Land Forms.—Fig. 13 shows the hill features in a bird's-eye view and also a corresponding contoured map, which should be carefully studied.

HILL FEATURES

Mountain. A mountain is an elevation usually more than 3,000 feet high.

Hill. An eminence less than 3,000 feet in height.

A **Plateau** is a broad tract of high level ground. It is fairly broad as compared with its length.

A **Ridge** is a long, narrow and fairly sharp-edged strip of high land.

Cliff. When the slope is very steep, the contours come very close together and may cut each other. This is the only case when the contours may intersect.

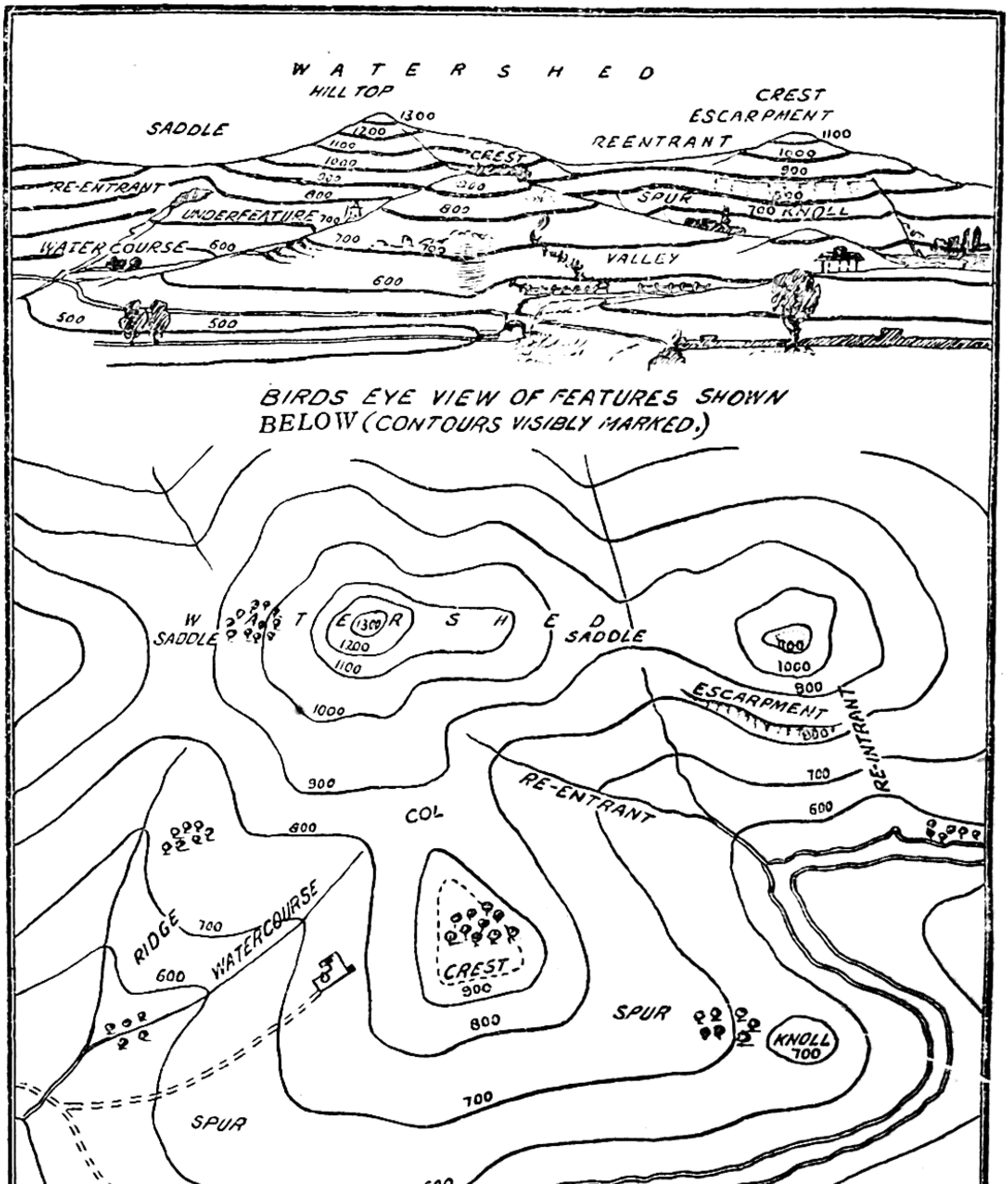

WATERSHED
HILL TOP
CREST
ESCARPMENT
SADDLE
REENTRANT
RE-ENTRANT
CREST
SPUR
KNOLL
UNDERFEATURE
WATERCOURSE
VALLEY
1300
1200
1100
1000
900
800
700
600
500
BIRDS EYE VIEW OF FEATURES SHOWN BELOW (CONTOURS VISIBLY MARKED.)
W A T E R S H E D
SADDLE
SADDLE
ESCARPMENT
RE-ENTRANT
RE-INTRANT
COL
RIDGE
WATERCOURSE
CREST
SPUR
SPUR
KNOLL

Fig. 13.

Crest or **Brow** is that part of the summit of a hill where the steep side changes to the flatter top.

A **Saddle, Col,** or **Neck** is the land connecting two hills or mountains. Passes are formed across saddles. It is a depression through which the ridge-line passes to connect the summits of a chain of hills. When a saddle is used to cross hills or mountains, it is called a **Pass**.

A **Spur** or **Bluff** is a tongue of land projecting from high ground into lower ground. It is shown by contours with points of V's pointing to lower ground.

A **Shoulder** is a broad, flattened spur with steeper slopes above and below it.

A **Re-entrant** is a depression in the side of a hill or sloping ground. All valleys are re-entrants, but all re-entrants need not be valleys.

A **Knoll** is a small hill or mound.

An **Escarpment** is an extended line of cliffs or is the steep side of a ridge. Steep slopes are often called escarpments.

DRAINAGE FEATURES

A **Valley** is the part of the ground lying between two slopes meeting at their bases.

A **Gorge** is a narrow opening between hills with steep precipitous sides.

Basin is the area of a country drained by a river and its tributaries.

A **Watershed** or **water-parting** or **divide** is the high ground from which the water falls on either side of two distinct drainage systems.

Watercourse defines the lowest line of a valley along which water runs.

FEATURES OF A GLACIATED REGION

Valleys which have been occupied by glaciers show well-defined characteristics :—

1. The rock surface is smoothed and rounded by ice.
2. The Valleys are U-shaped.
3. The streams from the sides flow in *Hanging Valleys*, and they form waterfalls.
4. Near the source, a rock basin similar to an amphitheatre or an arm-chair is hollowed out by the ice. These basins are called *cirques*.

*34. **Sections and Profiles.**—A section or profile from a contoured map gives us a definite picture of the relief along a line. With suitable modifications it could be made to illustrate features which otherwise would remain hidden. A *section* is the outline of the intersection of the ground by a vertical plane, or in other words is the surface formed when a solid is cut by a plane. When an apple is cut by a knife into two equal pieces, the freshly-cut surface of each half is a section.

A section has two scales :—

(*i*) The *horizontal* scale—This is always the same as that of the map from which it is drawn.

(*ii*) The *vertical* scale—This may be the same or some multiple of the horizontal scale.

Use a graph paper for drawing sections. Fig. 14 illustrates how a section can be obtained along *MN*. Draw perpendiculars from each point where the contour lines intersect the line *MN* to the equivalent height marked on the vertical scale. In this case the horizontal line is of the same length as *MN*. Join the various points thus obtained by a smooth curve.

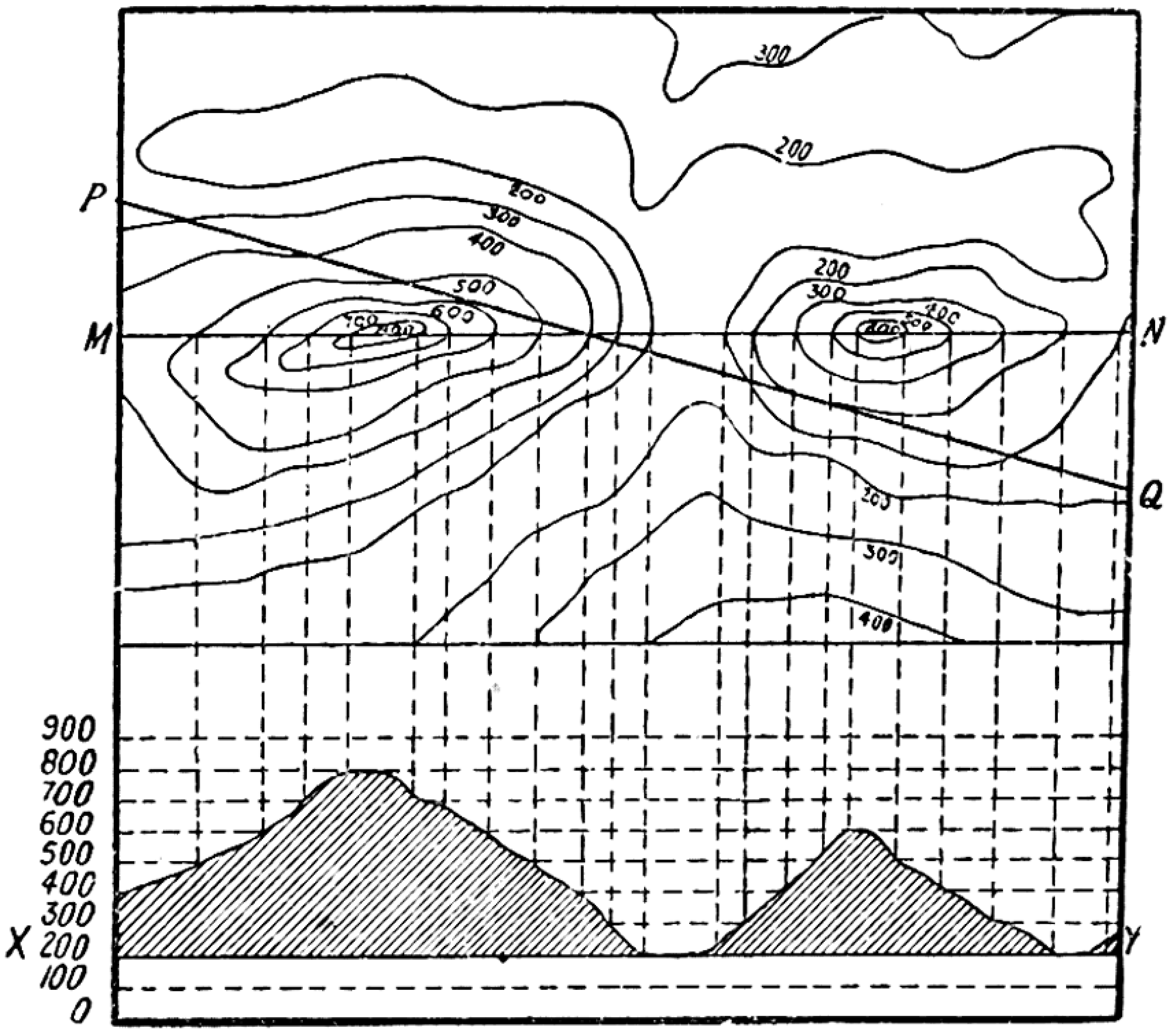


Fig. 14.

If a section along any other line say *PQ* is required; place a strip of paper along *PQ*. Mark the intersection of the contours along the edge of the paper, and transfer them to the new horizontal line drawn equal to *PQ*. Draw perpendiculars as before and complete the profile.

*35. **Intervisibility.**—An important problem in map-work is to find out whether two points are intervisible or what is the area of the ground not visible (called "dead ground") from any given point.

If the slopes are examined, visibility can be deduced from the contours by drawing a section along the points concerned. When the slopes are convex, the points are not mutually visible; if the slopes are concave the points are mutually visible unless prevented by some minor feature or any other obstruction.

EXERCISES

1. Draw contour maps to show the following features :—
   - (i) A hill-slope well dissected with streams.
   - (ii) A scarp facing south rising to 800 ft. cut through by a river (200 ft.) and two gaps at 500 ft.
   - (iii) A flat-bottomed valley in montainous country with a river flowing at one side of the valley.
   - (iv) An east-west gorge connecting two broad flat valley-bottoms.
   - (v) A spur 700 ft. high extending south-westwards from a plateau into a broad valley.
   - (vi) A south-flowing river emerging from a gorge into a wide flat-bottomed valley whose-western side is steep, other slope being gentle.
   - (vii) A highland mass rising to 1,500 ft. to the south-east of which are scarps (800 ft.) facing north-west and broken through by rivers.

2. What advantages have contours over other methods of showing relief ?

3. Illustrate by contours the various types of slopes.

4. How is a valley recognized on a contoured map ? How does it differ from a sloping ridge ? Illustrate by diagrams.

5. Draw simple contoured sketch-maps to represent the following land forms :—
   - (a) a dissected plateau.
   - (b) a mountain stream with a few tributaries and a lake.
   - (c) a ria type of coast or a fiord type of coast. (*Punjab, Univ., Inter., Sept. 1939*)

6. Show by means of contours the following :—a U-shaped valley, a V-shaped valley, a conical hill, a pass in high mountain ranges, a ridge with steep slopes. (*Muslim Univ., Aligarh, Inter.. 1939*)

7. What are contour lines ? Illustrate the method of drawing them. Show in contour language the following earth features :—
   (a) Spur (b) Col (c) Ridge (d) Re-entrant. (*Punjab, Univ., Inter., April, 1943*)

8. What are hachures ? Write a clear note on their value as a means to express relief on maps. How would you show the following earth features by hachures :—
   (a) a plateau, (b) a ridge, and (c) a conical hill with a gentle slope on one side and steep slopes on the other three sides ? (*Punjab, Univ., Inter., Sept. 1943*)

9. Write explanatory notes on the following and illustrate them by means of neatly drawn diagrams :—
   (o) cardinal points, (b) form-lines, (c) an escarpment, and (d) colour scheme in a physical atlas map. (*Punjab, Univ., Inter., Sept. 1943*)

10. What are the different methods of representing relief on maps ? Write short notes on each method and state which of these you consider best and why ? (*Punjab, Univ., Inter., April, 1945*)

CHAPTER IV

MAP READING

36. Conventional Signs used in Survey Maps.—In order to be able to read a map legibly, it is necessary to use distinctive symbols for various features. and use different types of letters for different purposes. These symbols are known as *conventional signs*. The conventional signs used in cartography are such as will convey all the information possible compatible with the general clearness and legibility of the map. Practice in drawing these signs is essential.

They differ for various types of maps ; for instance more symbols are used for 1 inch = 1 mile map than for 1 : 1,000,000 map ; symbols for the same feature are not always of the same size or type on both the maps. The conventional signs vary in every country but the general principle is the same. The conventional signs are shown on what is termed a *characteristic sheet* ;¶ explanatory diagrams are usually shown on the margin of Survey maps.

A good symbol is one which can be recognized without a legend.

If the real proportions were used.many symbols would be microscopic, hence the term conventional signs. For instance on a map of 1 to 1 million, a 20 feet wide road will show a thin line but topographic sheets show roads by double lines about $\frac{1}{40}$th inch part.

The symbols of a map may be divided into four groups :—

(1) Relief features (hypsography)—usually by various shades of brown.
(2) Water features (hydrography)—indicated by blue.
(3) Vegetation—shown in green.
(4) Man-made features (cultural)—usually shown in black and red.

Roads. In Survey of India sheets roads are shown by double lines in red. Metalled roads are shown by continuous lines and unmetalled by dotted lines. Arterial roads have two parallel lines in red, main roads two heavy parallel lines of medium thickness and ordinary roads two thin parallel lines in red.

In British Ordnance maps the spacing between the lines shows the class of road. The type of traffic for which it is meant is indlcated by colour ; red for fast traffic, yellow for ordinary traffic and broken yellow for rather bad roads, not suitable for vehicular traffic.

Roads are exaggerated in scale to make them prominent.

Bridle paths and foot-paths are shown by broken lines in red.

Milestones are marked by a numeral giving the distance.

¶Characteristic sheet of conventional signs can be had from the Survey of India Office. Hathibarkala, Dehra Dun.

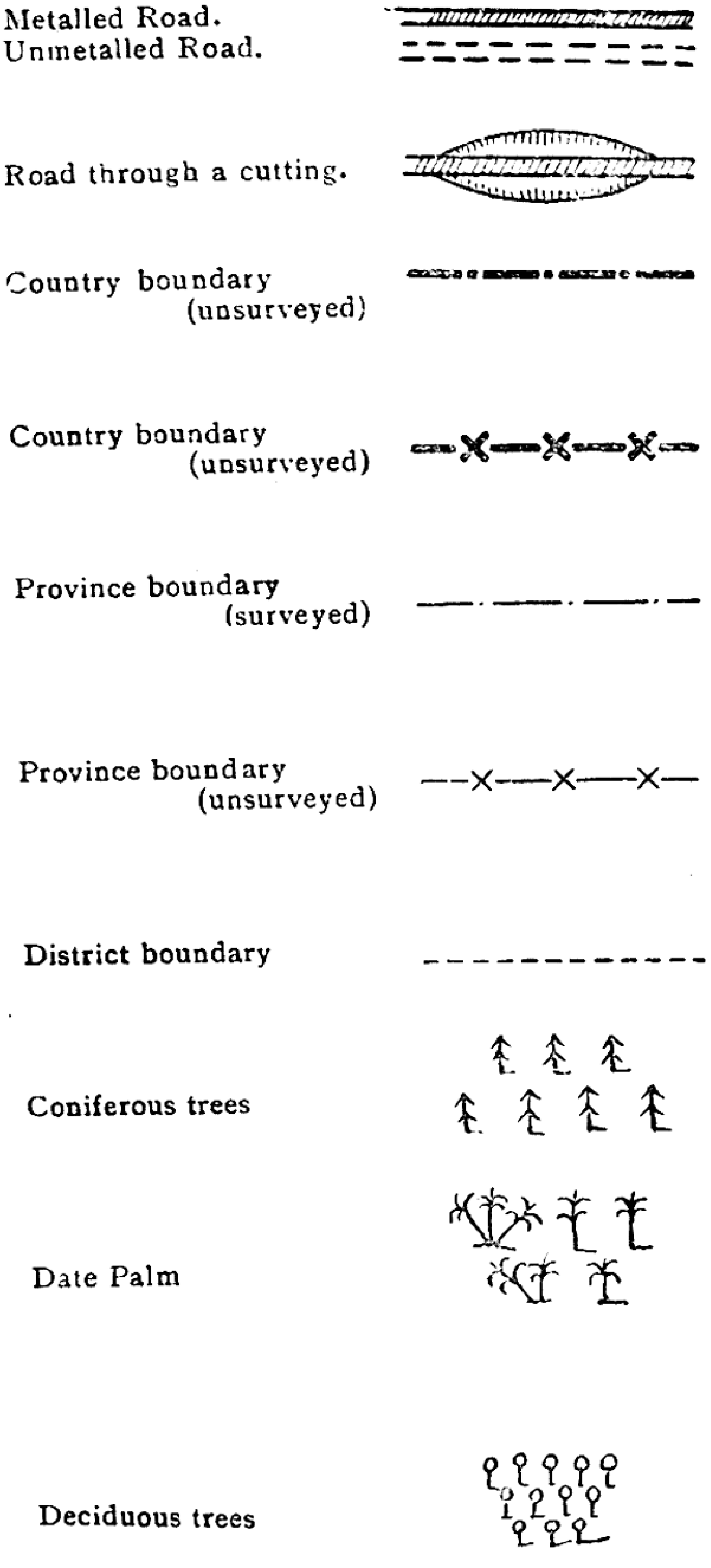

Metalled Road.
Unmetalled Road.
Road through a cutting.
Country boundary (unsurveyed)
Country boundary (unsurveyed)
Province boundary (surveyed)
Province boundary (unsurveyed)
District boundary
Coniferous trees
Date Palm
Deciduous trees

Fig. 15 (*a*)

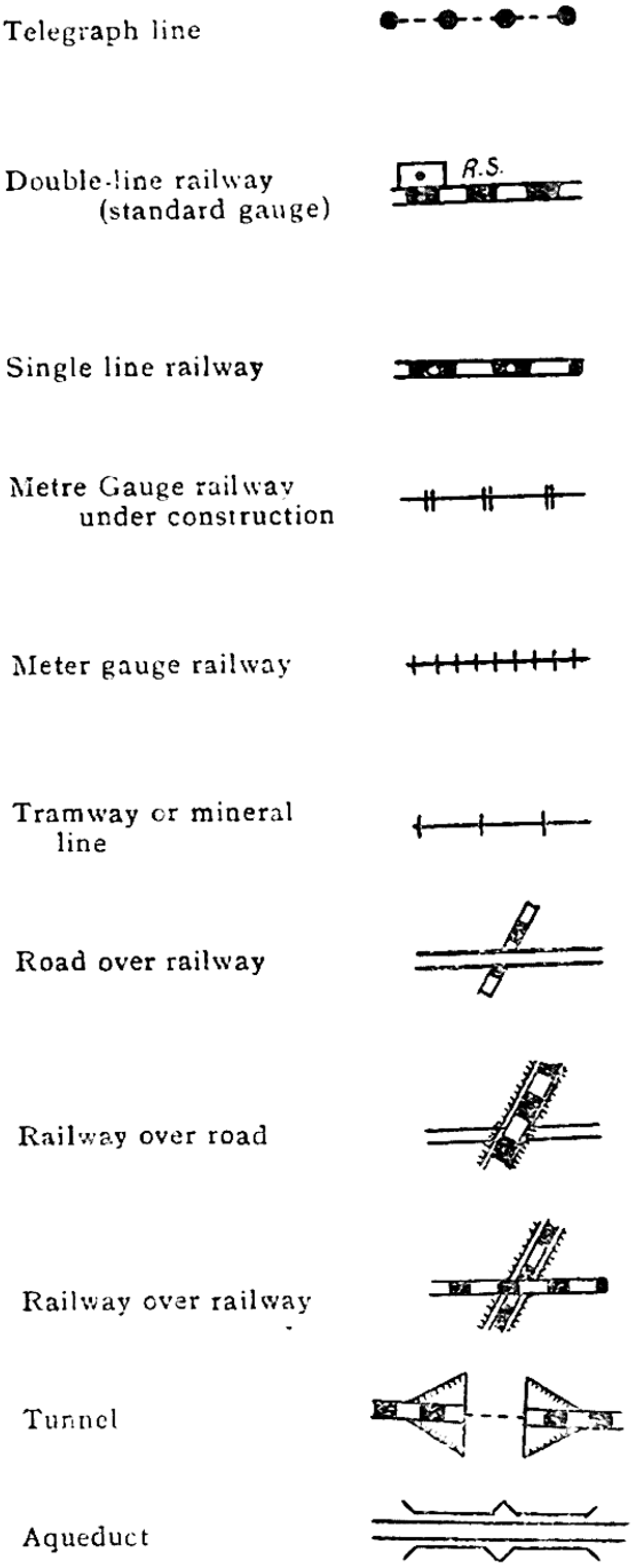


Fig. 15 (*b*)

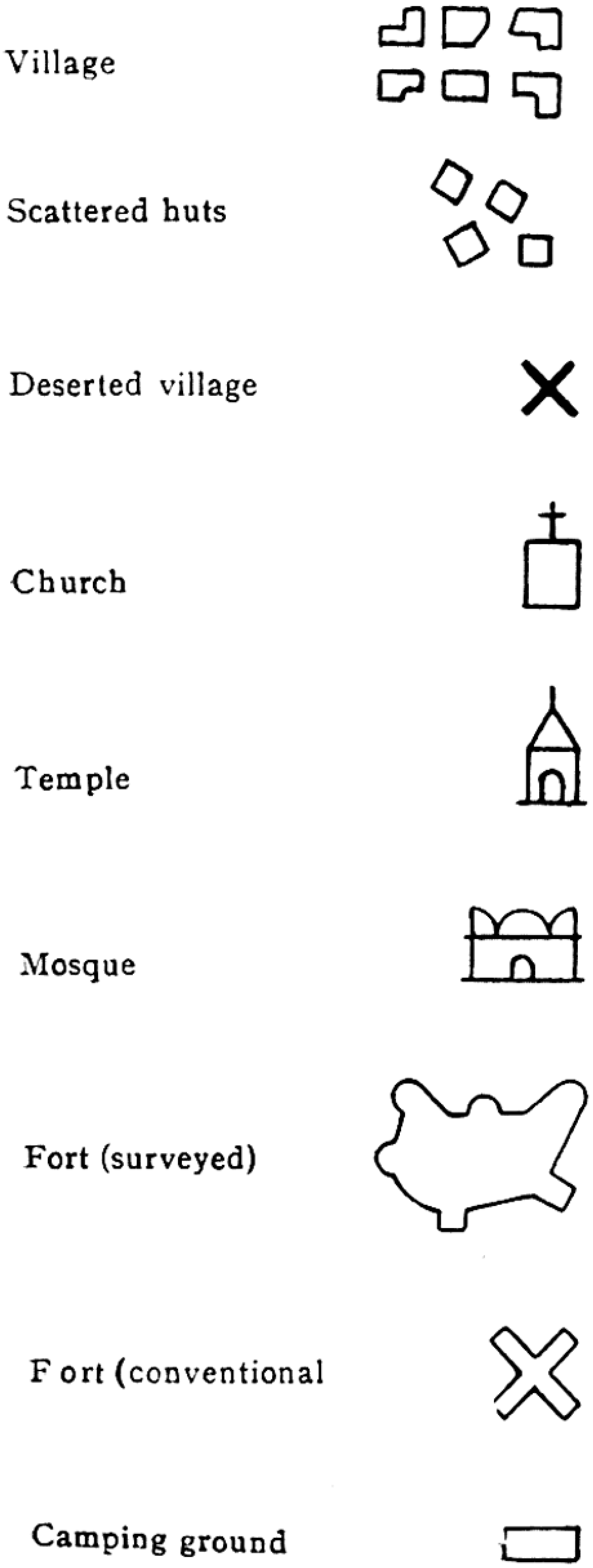


Fig. 15 (*c*)

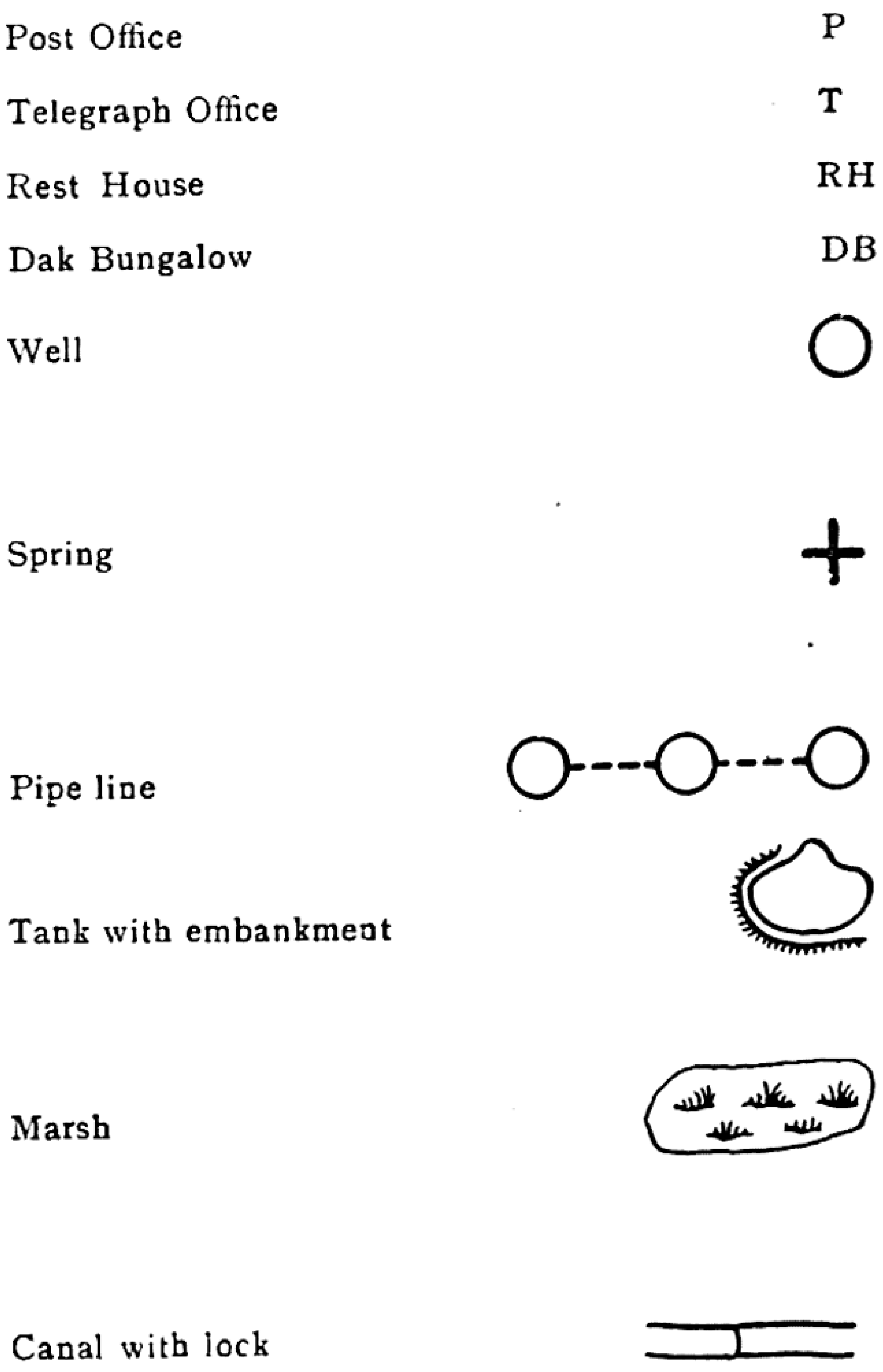


Fig. 15(*d*)

NOTE.—The symbols in Fig. 15 have been exaggerated in size. The student is advised to study these from a characteristic sheet, using a lens, if necessary.

Bench Mark. It is a fixed point that serves as a datum line from which other measurements can be made or checked. It takes the form of a broad arrow. (Abb. B. M.)

Railways are shown in black by double lines with short ticks between ; for a double line the alternate spaces are solid black.

In the case of embankments the hachures taper away from the railway line while in the case of cuttings the hachures taper towards the railway.

Rivers are shown by a double line with water lining. They are tinted blue on coloured maps. Rivers less than 15 feet in width are shown by a single line.

Canals are shown by double parallel lines in blue.

Marshes are shown by horizontal lines with little ticks above.

Pasture ground is shown by minute black ticks arranged in series.

Woods are shown by trees and tinted green on coloured maps.

Orchards are shown by small tree signs symmetrically arranged.

Parks are shown by a stippling of black dots.

Quarries are shown by a dark line from which spring short lines.

Buildings are marked solid black or red.

Boundaries. Boundary between provinces is shown by a thick peck-line, and that between districts by a dotted line.

It is not possible to reproduce all the conventional signs from the characteristic sheet. These sheets can be easily obtained and the symbols used are self-explanatory. These should be carefully studied.

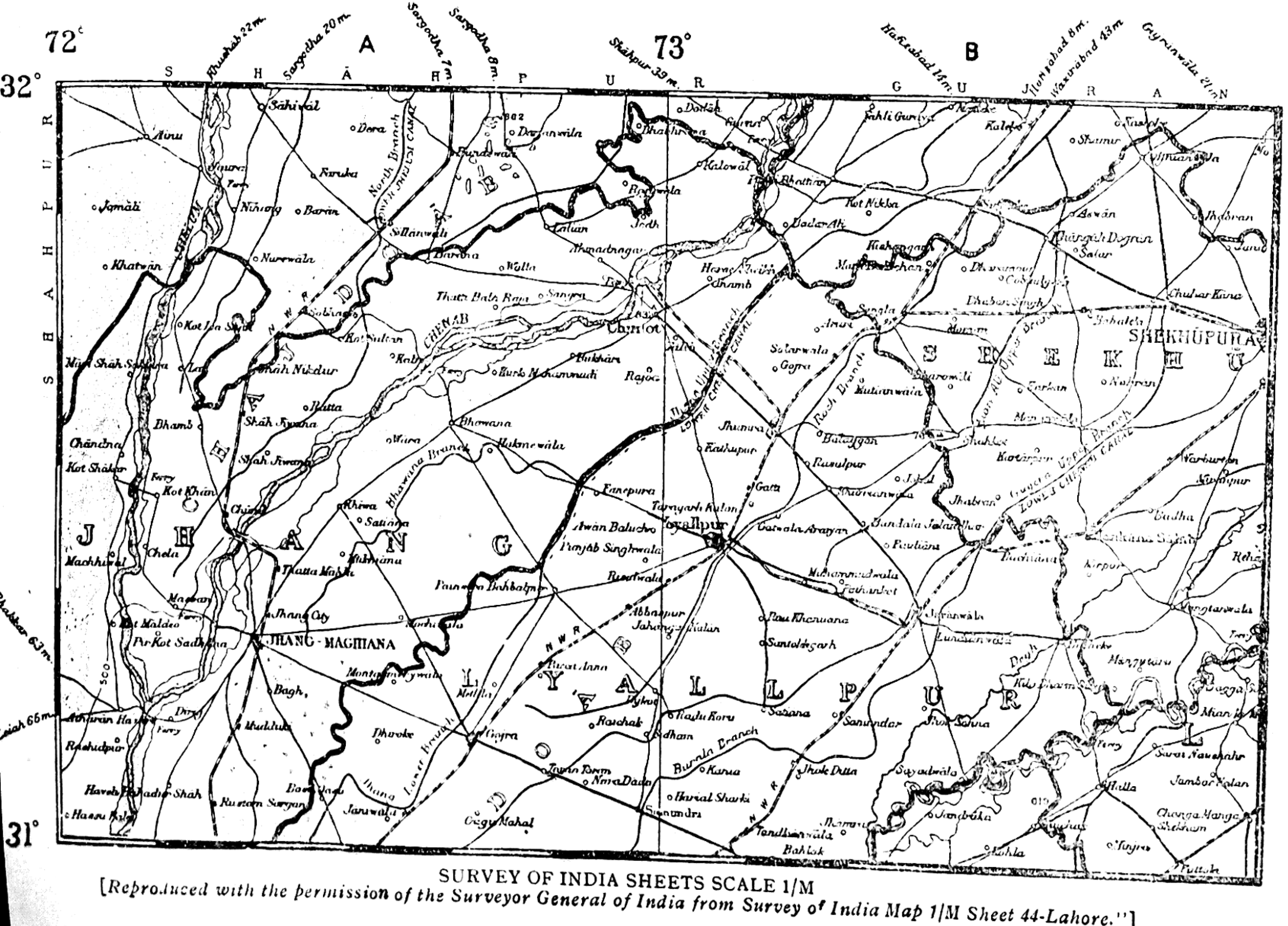
37. Marginal Information.—The following information of a general character is always shown on the margin of all maps, which must be carefully studied :—

(1) Scale, shown at the foot of the map.
(2) North point, shown on the top right-hand side and magnetic variation.
(3) Altitudes, given in feet ; heights shown by layer-tints or contours.
(4) Reference numbers.
(5) Legend (or Symbols) giving an abstract of more important conventional signs.
(5) Date of publication.

38. Proficiency in Map Reading.—The student is advised to purchase Survey of India sheets (Scale 1/M, *i.e.*, 1 inch to 1 million inches and one inch to one mile) of any familiar district and also the characteristic sheet giving the conventional signs. These maps can be had from the Map Record and Issue Office, Survey of India, Calcutta, Dehra Dun or Murree.

These maps should be studied systematically on the following lines.—

Remember that the interpretation should be from the evidence of the map alone. The material presented in the map should be collected and sorted. Then the sorted material should be classified in illustration of some aspect of Physical Geography or Human Geography or of both.



SURVEY OF INDIA SHEETS SCALE 1/M

[*Reproduced with the permission of the Surveyor General of India from Survey of India Map 1/M Sheet 44-Lahore.*"]

(1) **Preliminary Statement**. Describe the marginal information as given above Note the scale and calculate the area to give you an idea as to how much country is shown by the map.

(2) **Cartographic Methods Used.** Study the characteristic sheet appended to the map, the range of information available and the scope of symbolism. Classify in groups as explained in § 36 on page 24 and illustrate.

(3) **Physical Geography.** Give a general survey of relief and drainage. Draw a simplified sketch showing the relief features only (omitting minor details). Examine if the region can be sub-divided into well-defined types of country. Divide the area into two or three zones based on relief and study each zone under the following heads :—

(*i*) An analysis of relief—*i.e.*, slopes, heights, waterfalls, watershed, high ground, low-lying valleys, etc., any special features, *e.g.*, gaps and escarpments.

(*ii*) River work ; stage of development.

(*iii*) Glacial phenomena—erosion and deposition.

(*iv*) Coastal features—a separate physiographic unit—the work of sea as an agent of erosion and deposition.

(*v*) Is there any indication of the type of rock and soil ?

(4) **Vegetation.** Discuss the type of natural vegetation.

(5) **Human Geography.** Analyse and discuss the human response to physical environment. Draw a sketch of communications and human settlements.

(*i*) *Agriculture and Land Utilisation.*—Observe if there are moorland areas (for sheep) or meadows (for cattte) : area covered by marsh, wood land, orchards, gardens, arable land.

(*ii*) *Communications.*—Discuss the various means of commnnications ; the class, type, and the direction in which they run :—

(*a*) Bridle paths and small roads (*b*) main road (*c*) railways etc.

(*iii*) *Town sites.*—Examine the site of towns. Discuss the geographical factors that have influenced the growth of towns in the area. How are the sites related to relief and to various routes ?

(*iv*) *Industries.*—See if there are any mills, mines or factories and point out evidence, if any, of industrial development.

(*v*) *Recreation.*—Observe if there are any recreation parks, golf courses, rifle ranges, etc.

(*vi*) *Historical.*—Evidence if any of the occupation in the past ; observe camps, burial grounds, places of antiquarian interest. [These are usually indicated in Old English type. *e.g.*, Taxila].

(6) **Conclusion.** Divide the area into natural regions bearing in mind all previous deductions as to relief, vegetation, considered now in relation to human activities.

The most profitable way of studying a survey map is to select a map of an area well-known to you and study it in conjunction with practical work, *i.e.*, fairly detailed examination with a view to systematic geographical description.

EXERCISES

Select from the Survey of India 1/M and one inch survey sheets examples of maps representing different types of country and analyse them on lines suggested by the following questions :—

1. Reduce the scale and draw a sketch-map showing the relief and drainage. Suggest possible divisions into physiographic regions justifying such division.
2. On a reduced sketch-map show the distribution of villages and towns. Discuss the general distribution of population.
3. Explain how far the area is served by, and account for, the occurrence of different types of roads.
4. On a reduced sketch show the routes and towns and explain how far the sites of the towns and routes are influenced by physical features.
5. Identify and reproduce on a large scale the following features from the given map :— a water-shed ; a hanging valley ; col ; spur ; a scarped slope ; a conical hill ; a plateau ; a ridge.

---

6. Discuss the methods of showing (*a*) relief, (*b*) vegetation, (*c*) communications, (*d*) cultural settlements as shown on the given sheet.
7. Describe and illustrate the cartographical methods employed on the Survey of India maps on a scale of 1 : 1,000,000 which you may have studied. *(Punjab Univ., Inter., 1934)*
8. Describe the important topographical features of any selected Survey of India sheet (Scale 1 : 1,000,000) studied by you. *(Punjab Univ., Inter., 1935)*
9. Write a systematic geographical account of any Survey of India sheet (Scale 1 : 1,000,000) studied by you. *(Punjab Univ., 1936, 1937 & Supp. 1937)*

CHAPTER V

MAP DRAWING FROM DATA

39. Map Construction.—A description of a piece of land can be easily translated into a map if contouring and conventional signs used in map-work have been thoroughly understood.

In order to draw a contoured map note the following :—

(1) Read carefully the data supplied several times and fix the major features in the mind in their relative positions.

(2) Draw a rough sketch and write down the *names* of the features in their correct positions.

(3) Select a convenient scale and draw the border of the map in pencil bearing in mind the extent of the country to be shown.

(4) Draw the lowest and the highest contour lines.

(5) Insert the rivers and other major features.

(6) Select a suitable vertical interval and draw in all the contours now bearing in mind the shape these contours must take with reference to features already indicated, *e.g.*, when contour lines cut rivers, the points of V's should point to high ground, and in case of spurs to lower ground.

(7) Insert other features and means of communications and cultural settlements.

(8) Check the sketch and see if all the features required in the data are shown therein and nothing of an impossible nature (*e.g.*, a river flowing uphill) has been inserted. *Do not insert features not required in the data supplied.*

(9) Note that the contour lines must either form closed chains or run to the edge of the map. Do not crowd the map with contours to obscure other features; nor should the contours be too few. Strike at a mean consistent with data and neatness of the whole sketch.

(10) Ink the map showing the contours in brown or red, and using conventional signs for various features. Label the necessary features etc.

(11) Draw the border : scale ; show north, and give a key to all the symbols used.

Example 9. *Construct a map showing by means of contour lines at 100 ft. intervals the following features.*

***A long ridge runs from west to east.** Its crest is on the average over 600 ft. in height, but it is notched in three places by gaps and is completely broken through by a river which is flowing from south to north. The ridge on the northern side sinks gradually to a marshy plain. The slope on the southern* *side is steep in its upper portion and then becomes more gradual. The country to the south of the ridge is broken, undulating and wooded. Near the point at which the river begins to cut through the ridge on its southern side, is a town with a church, situated on an isolated hill. A main road and a railway pass through the river valley, while secondary roads make use of the other gaps.* (See Fig. 16).

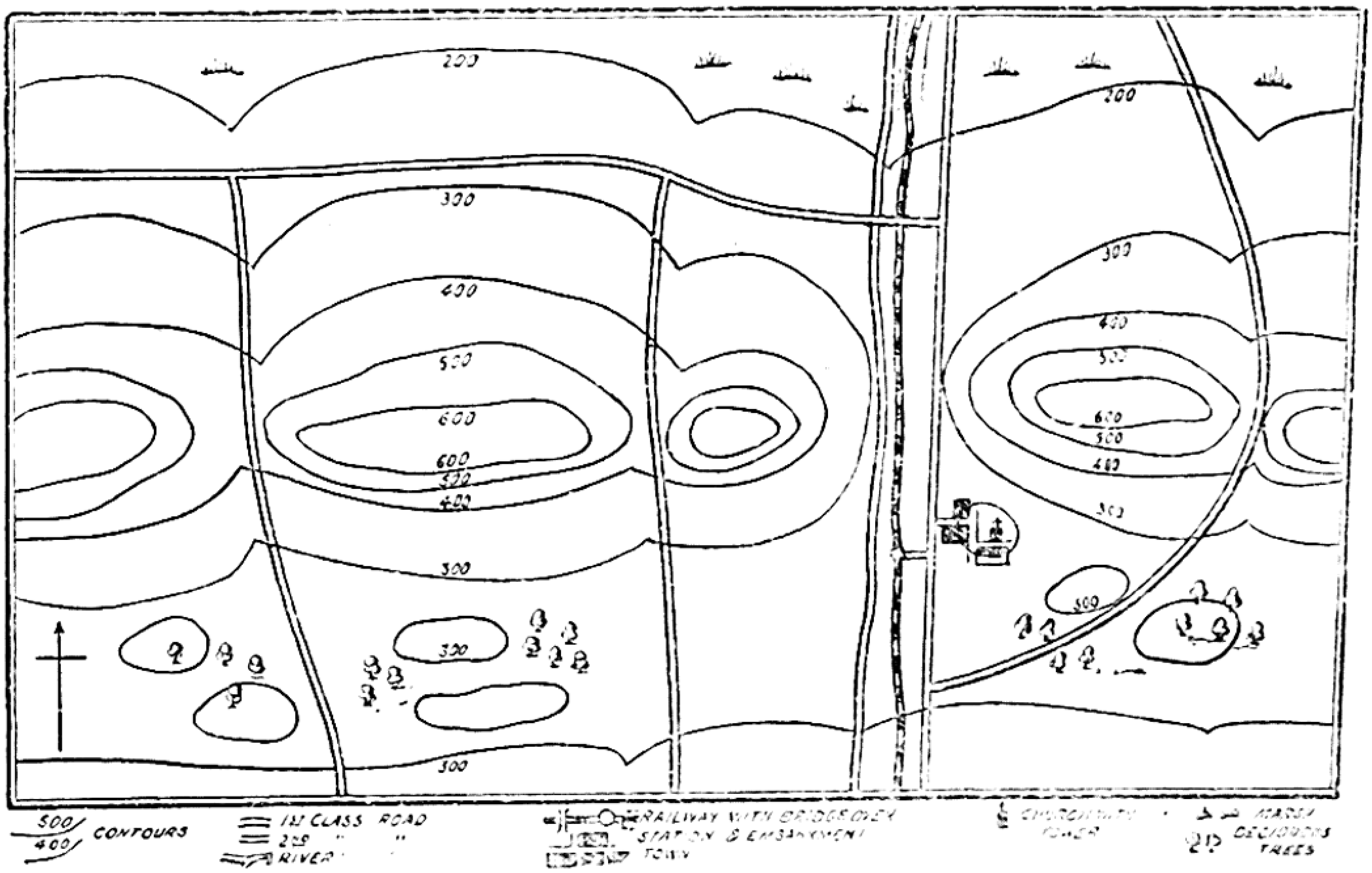


Fig. 16.

40. Copying Maps.—A map may be copied on tracing paper by placing it over the original. It is a saving of time to trace it direct in ink.

* **41. Enlarging and Reducing Maps.** Map enlargement. which is very simple in its principle is of considerable importance in modern warfare. Small-scale maps are supplied to the military staff. The minor features, which may be of military importance, are not marked. Hence an enlargement of the small-scale map is made and the additional information is completed on the site as may be necessary. The following methods are commonly used :—

(1) **The Methed of Squares.** Draw a network of unit squares over the map to be copied, reduced or enlarged. Prepare another netwerk of squares on a blank drawing paper, with their sides reduced or enlarged by the factor chosen. Insert the detail by eye, square by square.

The greater the number of squares, the more accurate will be the enlargement or reduction.

(2) **The Method of Similar Triangles.** This method which is much simpler than the above is used for routes etc. From any convenient point, lines are drawn to the salient points of the original route. The ends of the route are joined to form a triangle. If it is desired to reduce the map, another point on the side nearer to the first point, proportional to the required scale is taken and the route is then sketched in. If an enlargement is required the second point is taken on the side further to the first on producing the sides of the triangle.

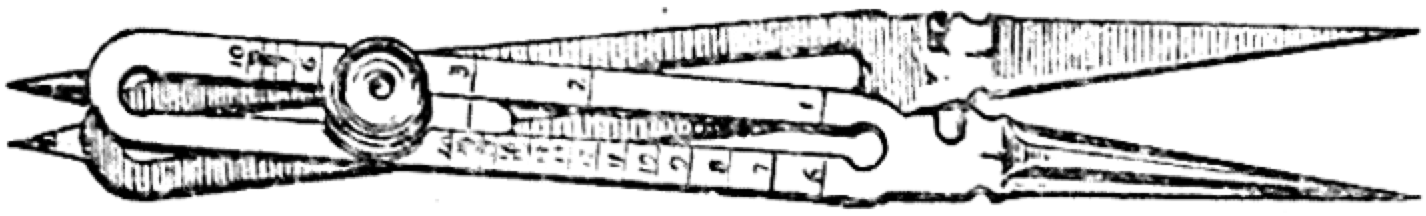


Fig. 17.

The Proportional Compass (Fig. 17) is a simple instrument based upon the above principle.

(3) **The Pantograph** is an instrument for copying, enlarging or reducing maps. Its principle will be readily understood by using it.

(4) A map may also be enlarged or reduced by the photographic process.

42. Lettering.—A good map may be spoilt by careless lettering. It is necessary that all names on the maps must be clear, legible and neat in appearance. Lettering is a tedious task hence no attempt must be made to make it very artistic and only such style should be adopted as should be neat and fairly rapid to execute. The following points must be borne in mind :—

(1) Select a style which approximates to your natural handwriting.

(2) The spacing between letters must *appear* even ; the shape and size of the letters must be uniform ; *e.g.*, the space between two O's is less than that between two I's.

(3) Use a stiff and broad pointed nib. A springy nib is not good for lettering. Do not use a fountain-pen.

(4) For most lettering there are two styles :—the Roman (or the upright) and the Italic (or slant lettering), *e.g.*, LAHORE. ; ***LAHORE.***

Land features are shown usually in Roman and water features in Italic style. Ornamentation must be avoided.

Remember that,—

By the **style** of your letters, you differentiate the various features, *e.g.*, mountains and rivers.

By the **size** of your letters you express the importance of these features.

By the **spacing** between the letters you express their extent.

All letters must read in the *same* direction.

EXERCISES

1. Draw a sketch map of a village with a post and telegraph office, a church with spire, and an inn. A main route passes through it and two foot-paths cross the main route in the village.

2. On a scale of 1 mile=1″ draw a contour map of an island 4 by 2 miles, with the ground rising to a hill whose summit is a mile from the eastern shore and is 800 ft. high. All slopes are concave. [Vertical interval 100 ft.]

3. An island 6×4 miles has two hills, one 400 ft. and the other 200 ft. high. Slopes below 200 ft. are gentle ; those above 200 ft. are steep. Insert a river and a road across the island. Draw a contour map on a scale 1 mile=1″ and V.I. 50 ft.

4. Using a suitable scale draw a map having an area of 150 sq. miles. By means of contour lines represent the following features :—

A mountain range runs from S.W. to N.E., rises to a height of 2,000 ft., slopes steeply to the S.E. and more gently to the N.W. A stream rising on the N.W. slope runs N.W. into the sea after crossing a plain. Along the coast are sea cliffs over 300 ft. in height.

Make a section which will best show the character of the country.

5. Draw a contoured map showing the following features ; a plateau about 1,000 ft. in average elevation terminates eastwards in a steep escarpment overlooking a low plain. To the west it sinks more gradually to the sea, but a ridge of high land connected with the plateau forms a bold promontory. Three streams which have excavated deep valleys in the plateau unite in a river which flows out south of the promontory. [V.I. 50 ft.]

6. Draw a contour map illustrating a deep-river valley with hills rising 2,000 ft. on the right bank of the river and 4,000 ft. on the left bank, and crossed by a railway through mountain passes of not more than 300 ft. above sea level. *(Punjab Univ., Inter., April 1941)*

7. Draw a map illustrating the following features : A town lies in the centre of a plain about 100 miles square. The town is on a small island in the main stream of the plain, which drains westward. The town is at the head of navigation. The plain is at the focus of continental routes from the East and South. The sea is 50 miles from the town on the North and West, but the river course below the town is about 80 miles long. [Scale 16 miles=1″.]

8. What is meant by a contour map ? Draw one to show an island rising steeply on its eastern side, and gently on its western side, to the central highest point of 600 feet above sea-level. Insert a river valley terminating south in an estuary two miles long. Indicate the best route for a road across the island.

9. Reduce the map in Q. 8 to half the scale.

10. Enlarge the Red Sea from a map of Africa in your atlas to double its scale.

11. On a scale of 1 : 40,000 construct a plan of a village which extends 4 miles east and west and 3 miles north, and south showing huts, metalled and unmetalled roads, foot-paths, lined and unlined wells, an unlined tank, a canal, a garden, arable and waste land, post and telegraph office and a railway station on a narrow-gauge line. *(Punjab Univ., Inter., 1933)*

12. Draw a contoured map of any area that you may have studied. Show lines of communication, flow of streams and human settlements.

Write a short geography of the area you have mapped. *(Punjab Univ. Inter., 1935)*

13. Draw a map of a small area that you may have studied. Show by means of signs used on the Survey of India sheets, the main topographic features and facts of human geography. *(Punjab Univ. Inter., 1936)*

14. What is a contour ? A rectangular area with its longer side east and west measures 18 miles by 7 miles. A mile south of the northern edge lies the crest of a mountain ridge of which the peaks reach between 800 and 900 feet. A spur is thrown off about seven miles from the eastern end of the range and descends irregularly to the south, falling to 300 feet at the southern edge of the area. The floors of the valley east and west of this spur are as low as 200 feet. Make a contoured sketch map of the area on scale of 1″=2 miles. *(Punjab Univ., Inter., Sept. 1941)*

15. Draw a contour map of an island with particulars given below, taking care to use a suitable scale, inserting contour lines at intervals of 100 ft. and an arrow to indicate the North :—

The island is 16 miles long from north to south and 12 miles wide. On it are two peaks : one in the north is 4500 ft. high and one in the south 3400 ft. The col between them is between 400 and 500 ft. In the north-west is a village X and in the south-west is a lake surrounded by hilly country with one long and three short rivers falling into it. On the east coast there is another village Y· These two villages X and Y are connected by a road and a railway. *(Punjab Univ. Inter., April, 1946)*

16. Draw a contoured map to show an island with two hills, 900 and 700 feet in height separated by a saddle 600 feet high. The island rises steeply on its eastern side and gently on the western side : the slope on the north is uneven and terminates in a plane. Insert a river valley terminating south in an estuary two miles long. Also draw a section which would indicate the best route for a road across the island. Draw contours at intervals of 100 feet. *(Delhi Univ. Higher Secondary, 1946)*

CHAPTER VI

DISTRIBUTION AND STATISTICAL MAPS

43. Distribution Maps.—Distribution maps show the variation in the value, amount or density of various distributions, usually stocks, crops, minerals, and the density of population. They help the geographer to study the cause and effect, say, of the density of population of any area or of the large scale production of any crop in any area. To complete our enquiry into the factors which control the distribution of any commodity, or of man, it is necessary to study the distribution maps in conjunction with physical and climatic maps. For instance, the sources of our wool supply depend upon the distribution of sheep, which depends on both physical features and climate. Sheep do not like much heat or damp, and in tropical regions they thrive only where the heat is modified by altitude.

***44. Stocks and Crops.**—The following methods are used to represent stocks and crops on distribution maps:—

(1) *Writing the name of the commodity.* The name of the commodity is printed in capital letters or in rectangles across the area where the particular commodity is produced thus—RICE. This method is qualitative and does not give us any quantitative idea of the commodity produced. Thus the word RICE printed over the Ganges delta only shows us that rice is produced in Lower Bengal, but it does not convey any idea of the quantity of rice produced per year or the total quantity produced in a year or in an average of five years. Moreover there may be stretches of unfavourable soil, in the same area where rice is not cultivated.

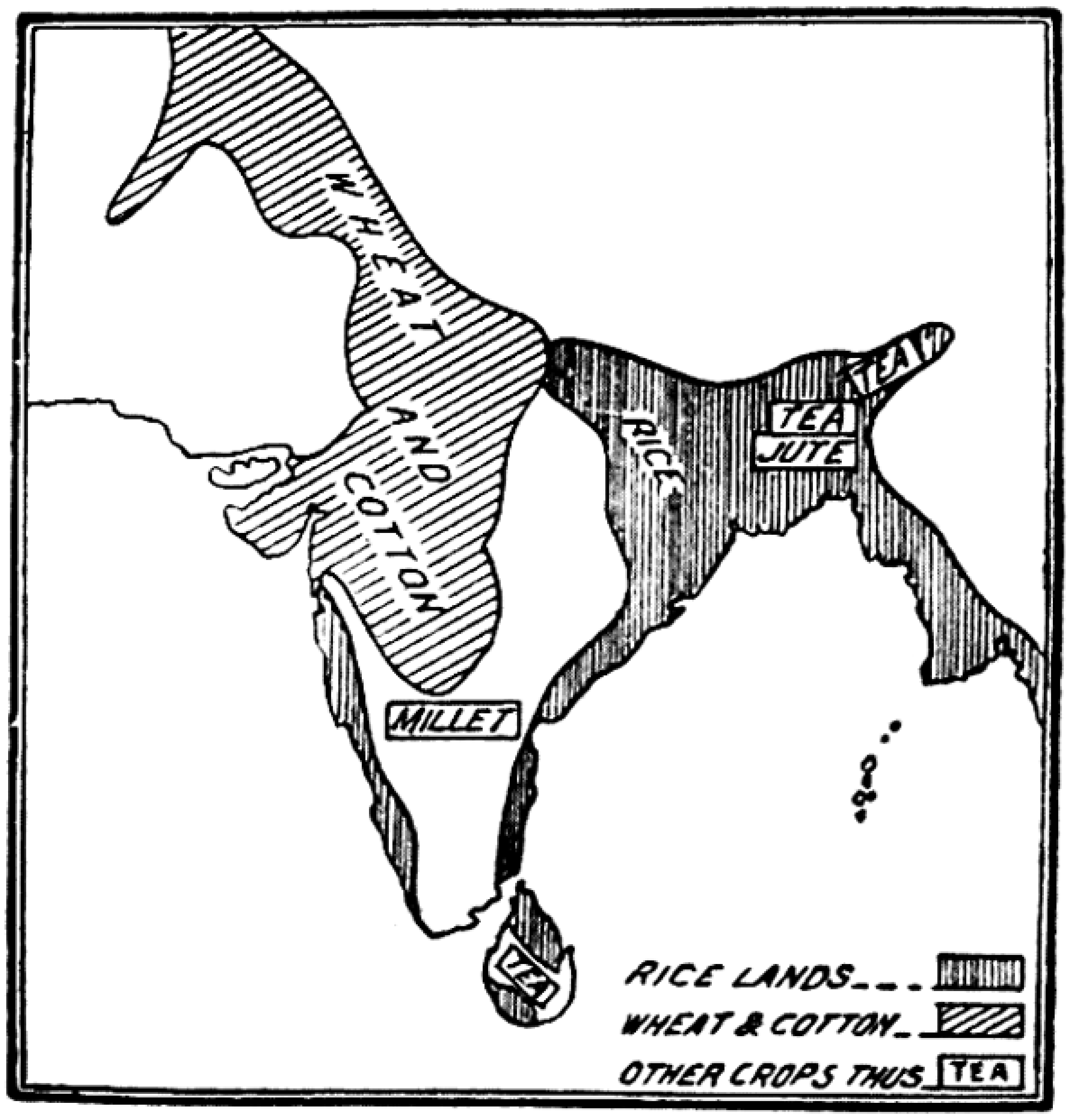


Fig. 18.

(2) *Shading or Layer Tint Method.* Distribution is shown by various methods of black and white shading or by different tints of colours. This method is useful for average figures per unit area.

The chief defect of this method is that the distribution is shown uniform over the whole area, and no account is taken of waste-land.

If colours are used instead of black and white shading it is better to use one colour for each commodity using various tints or shades for various densities.

Fig. 19 shows the key to black and white shading.

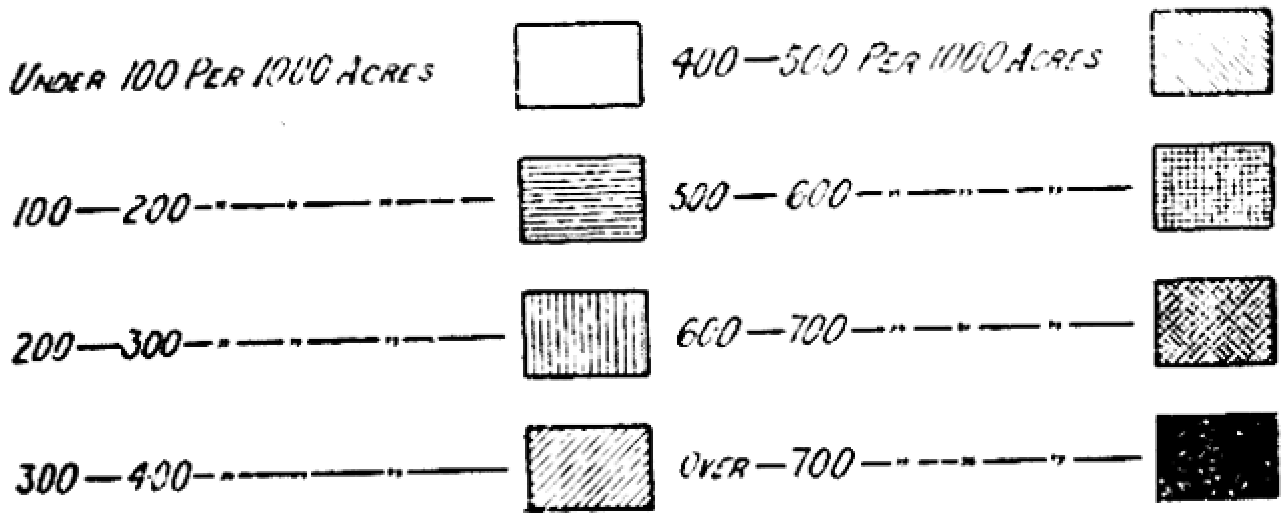


Fig. 19.

(3) *The Dot Method*. This method is useful for absolute figures, *i.e.*, when exact or absolute figures are available. A unit number, say 1,000 to 5,000 according to density and scale of the map, is represented by one dot over the place it is cultivated. The advantage of this method is that the waste land may be avoided. The unit must be selected with care. The dots must not be too numerous; nor must they be too small. [See Fig. 20.]

Apart from stocks and crops, the dot method may be used in many other cases, *e.g.* :—

(*i*) In a coal-field map, for the sites of coal-mines. The size of the dot can be varied according to the number of men engaged in each mine.

(*ii*) Sites of fairs, markets, factories, etc.

45. *Population Maps.—Population maps may be of two types :—

(1) Showing the number of persons per unit area; shading or colour layer method is most suitable for these maps.

(2) Showing actual population; the dot method, using a convenient unit, is generally used for these maps.

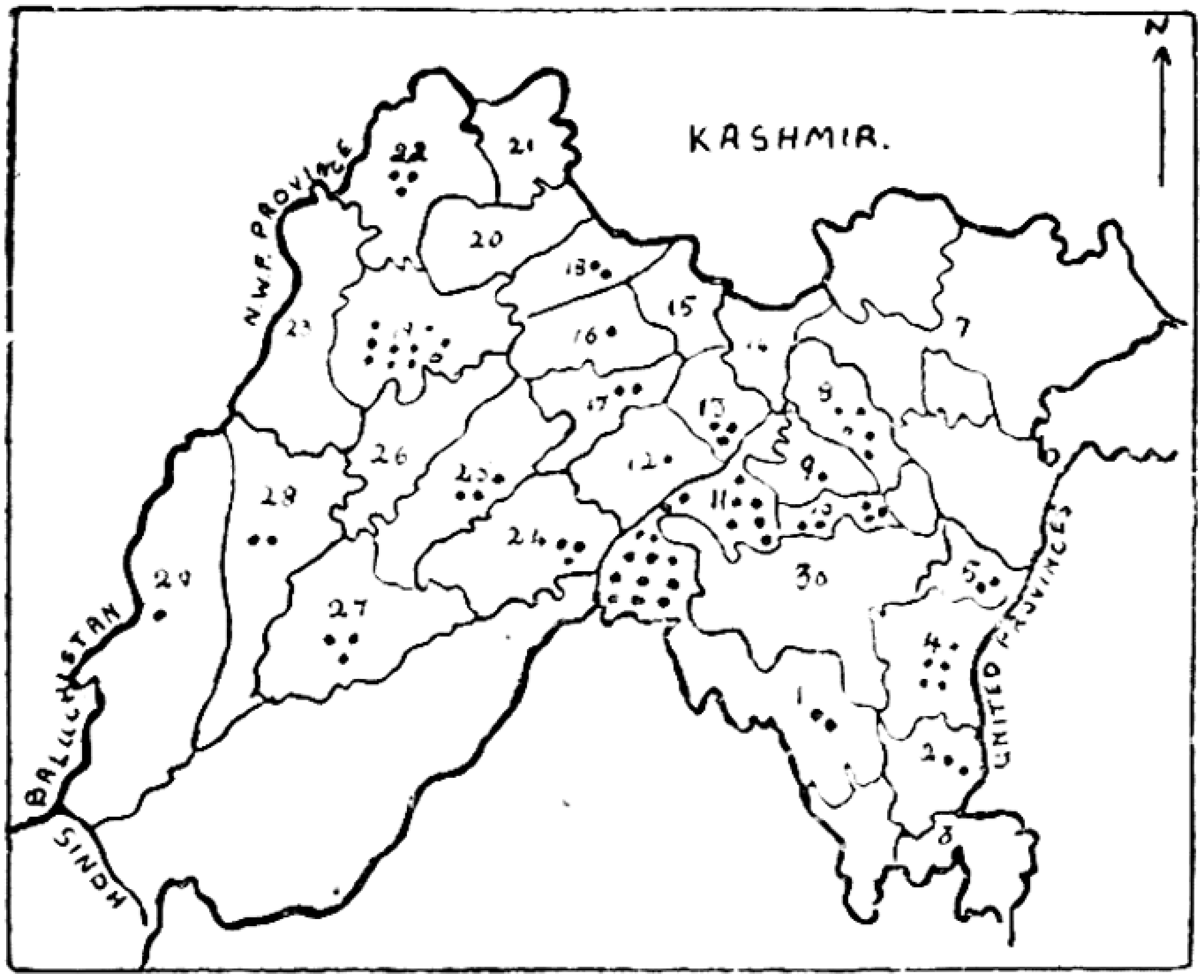
Sometimes the shading and dot method are combined, so that the same map would give the average and actual figures.

NOTE.—Distribution maps have certain limitations. Numbers vary greatly from season to season, and year to year. A map made on one year's figures will not give us a true picture. Moreover the year selected may be an abnormal year. These maps are usually based upon statistics for an average term of years, usually five years.

Population maps are based on census returns which are made once in ten years.

46. Statistical Diagrams.—Statistical diagrams show at a glance the meaning and importance of the facts and figures with reference to the exact figures.

MAP OF THE PUNJAB, SHOWING THE YIELD OF GRAM. YEAR 1938—1939



Scale : (one dot=50,000 tons)
Fig. 20.

MAP OF THE PUNJAB SHOWING DENSITY OF POPULATION IN THE YEAR 1931

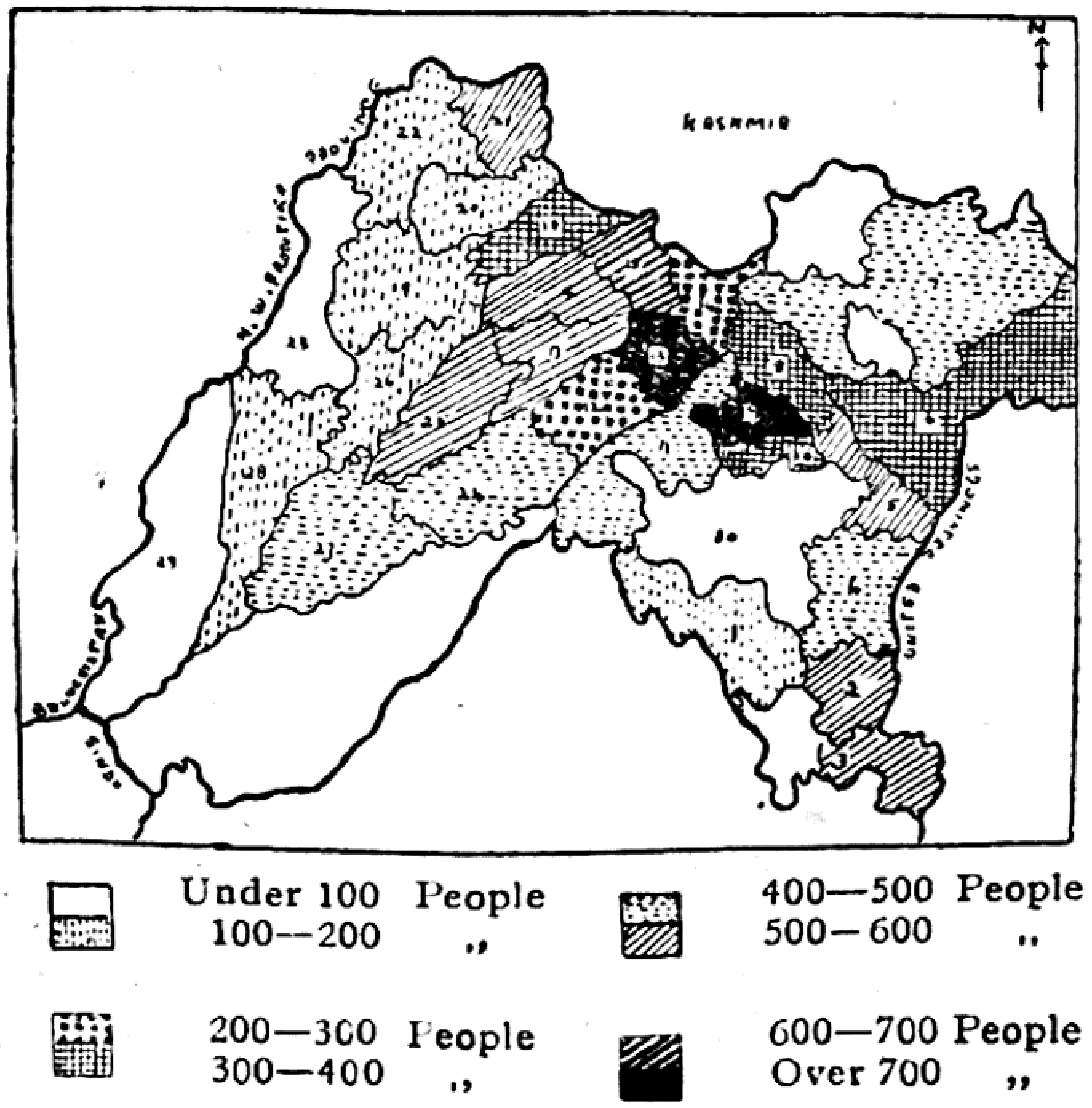


Fig. 21.

Table showing the number of people per square mile.

1.	Hissar ...	174
2.	Rohtak ...	354
3.	Gurgaon ...	384
4.	Karnal ...	271
5.	Ambala ...	397
6.	Simla ...	454
7.	Kangra ...	206
8.	Hoshiarpur ...	457
9.	Jullundur ...	703
10.	Ludhiana ...	482
11.	Ferozepur ...	284
12.	Lahore ...	531
13,	Amritsar ...	710
14.	Gurdaspur ...	510
15.	Sialkot ...	624
16.	Gujranwala ...	320
17.	Sheikhupura ...	301
18.	Gujrat ...	405
19.	Shahpur ...	171
20.	Jhelum ...	133
21.	Rawalpindi ...	309
22.	Attock ...	140
23.	Mianwali ...	76
24.	Montgomery ...	224
25.	Lyallpur ...	354
26.	Jhang ...	146
27.	Multan ...	220
28.	Muzaffargarh ...	200
29.	D.G. Khan ...	106
30.	Punjab States ..	96

Isopleths are lines on the map which connect places of equal density or value of distribution of any element ; *e.g.*,

Isotherms, connecting places of equal temperature ;

Isohyets, connecting places of equal rainfall ;

Isobars, connecting places of equal pressure.

Contours, which connect places of equal height, may be regarded as Isopleths.

The following methods are usually used :—

(1) **Line Graphs.** By a graph showing the variation from year to year. In general, it shows change of one variable with reference to another. One of the variables is usually time (days, months, years, etc.) When a line graph shows a continuous variation, *e.g.*, pressure, temperature, the points must be connected with a continuous smooth curve. If it shows a non-continuous variation, *e.g.*, the price curve of a commodity or rainfall, the points should be joined with a jagged line.

The vertical scale should be so selected that the curve should not show too sharp a vertical variation.

By using charts of the same size and which have the same scale intervals, comparison may be made between different charts by arranging them one above the other or by arranging them horizontally end to end.

(2) **Bar Graphs** are used for simple comparison of quantities. It is used for comparing magnitudes when only the sizes vary. For instance, we may compare the population of the various towns of the Punjab, or the number of students offering various subjects in your college, or profits made on sales of wheat with those on cotton. Hence for graphic representation of sizes the comparisons are made by using certain geometrical forms *viz.*, straight bars, rectangles and circles. The quantities are shown by bars of equal width, the length being proportional to the quantity on a suitable scale. The bars could be vertical or horizontal : in horizontal bars, the labels are more easily read.

Bar graphs are not satisfactory when one quantity is several times larger than the other.

Bars can be conveniently sub-divided and the sub-divisions marked by different tints or shading. If two different related variations are shown, two tinted or shaded bars may be placed side by side, *e.g.*, number of students in various subjects sent up for the Intermediate Examination and number of students passed in each subject.

Sometimes bars are shown on both sides of a vertical zero line ; such diagrams are known as *Mirrored bar graphs*.

(3) **Rectangular Diagrams.** In these diagrams a large area, *e.g.*, a continent or a country is sub-divided into small regions, each of which is represented by a rectangle. The rectangle is proportional in area to the value it represents. It is better to begin with the larger division and arive at the smaller ones by proportionate halving. Calculations can be made easily if it is drawn on graph paper, so that one small square of the graph paper corresponds to a round number of units.

If one of the variables is time, the production or price of any commodity can also be shown by rectangular diagrams.

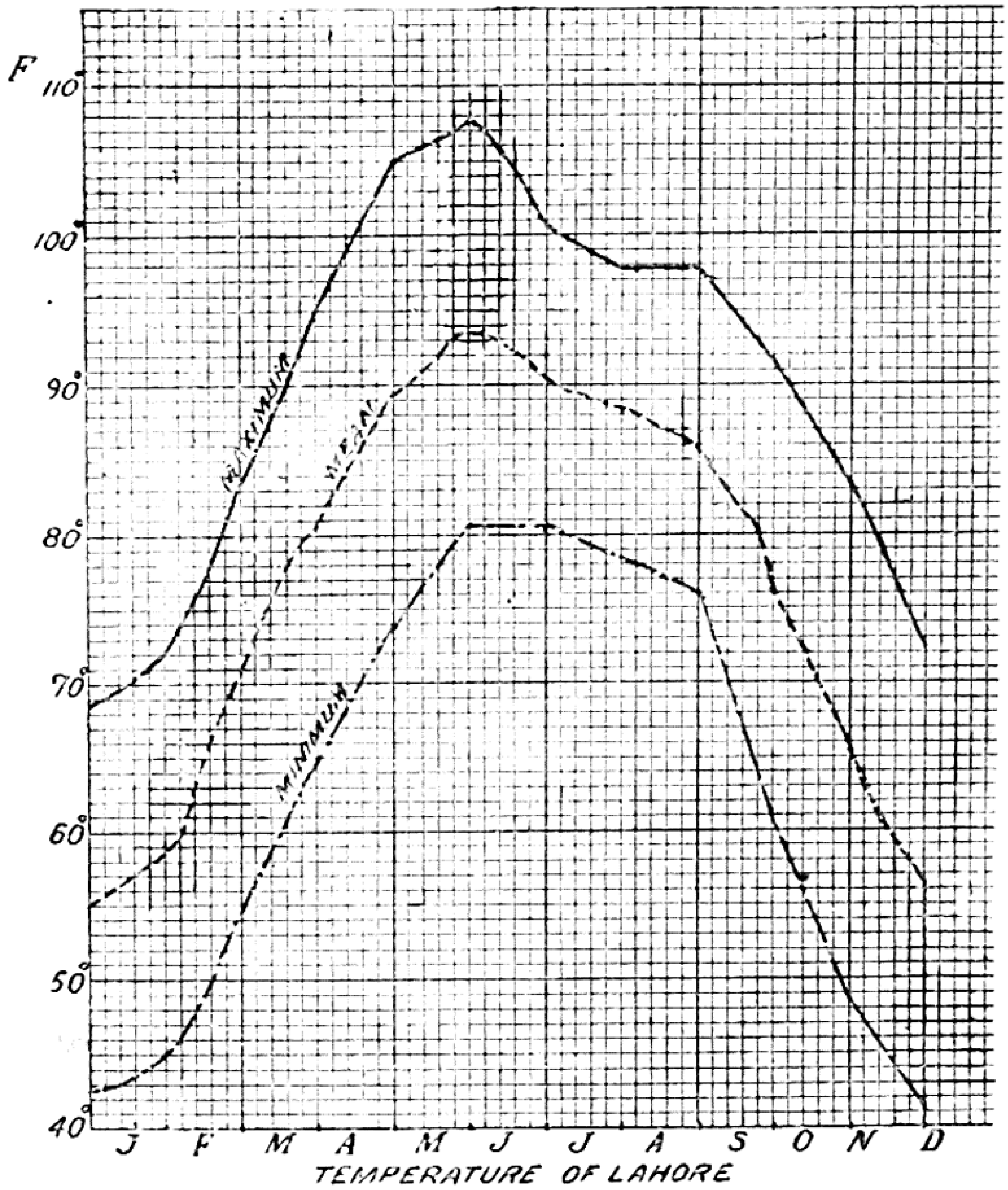


Fig. 22A. Line Graphs.

(4) **Pie Graphs** or **Wheel Diagrams.** The distribution is shown by circles of different sizes, the area of each circle being proportionate to the quantity or amount to be shown. The radii of circles are proportionate to the square roots of the quantities.

The circles may cut into each other if this does not make the map confusing. The circle may also be sub-divided and the sub-divisions marked with various tints.

Pie graphs are used when the data are not sufficient to prepare a dot map or when the distribution is strongly localized, *e.g.*, on a map showing water power or production of Petroleum, or when the circles are further sub-divided.

The following points must be remembered in drawing isopleths :—

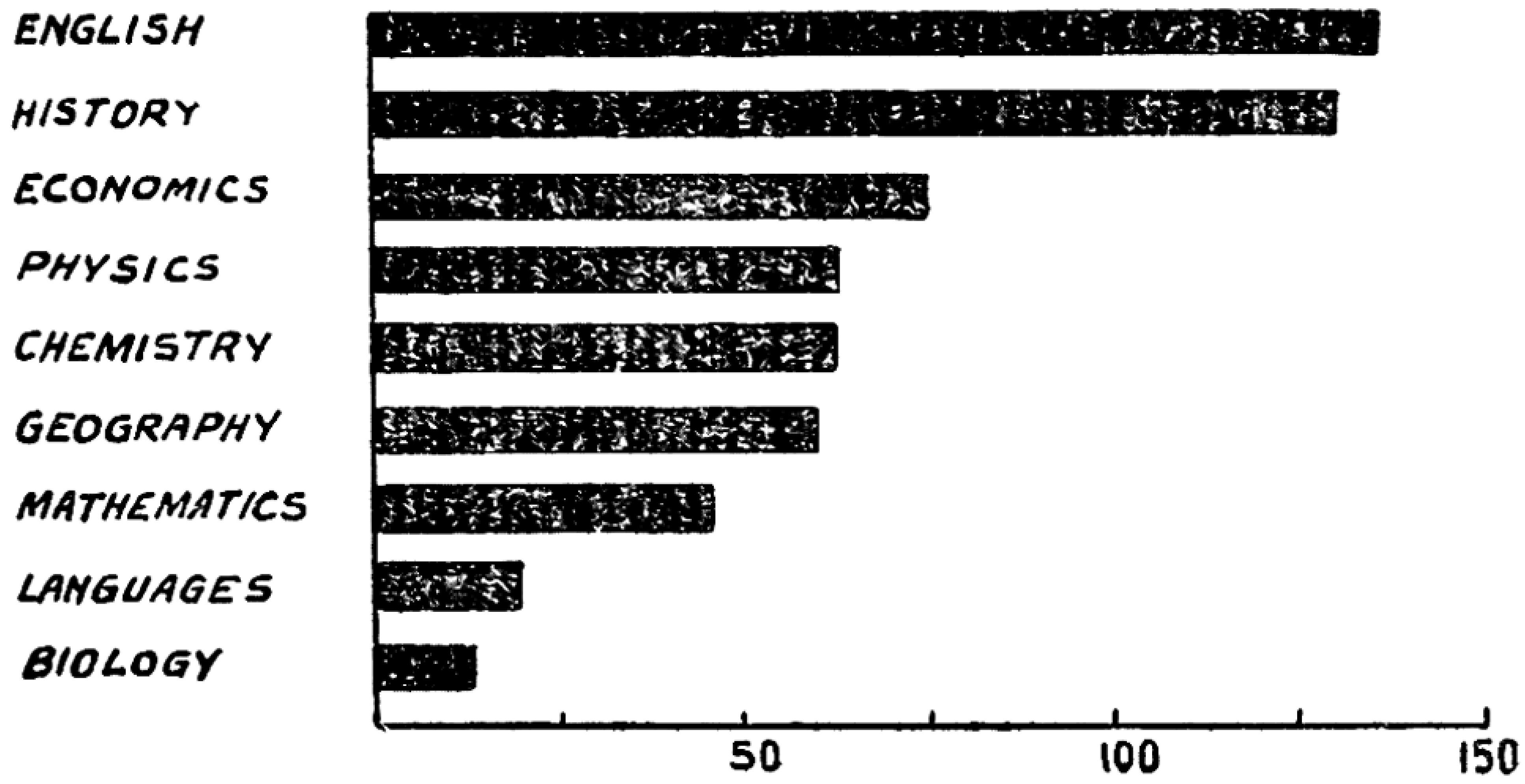


Fig. 22B. Bar Graphs.

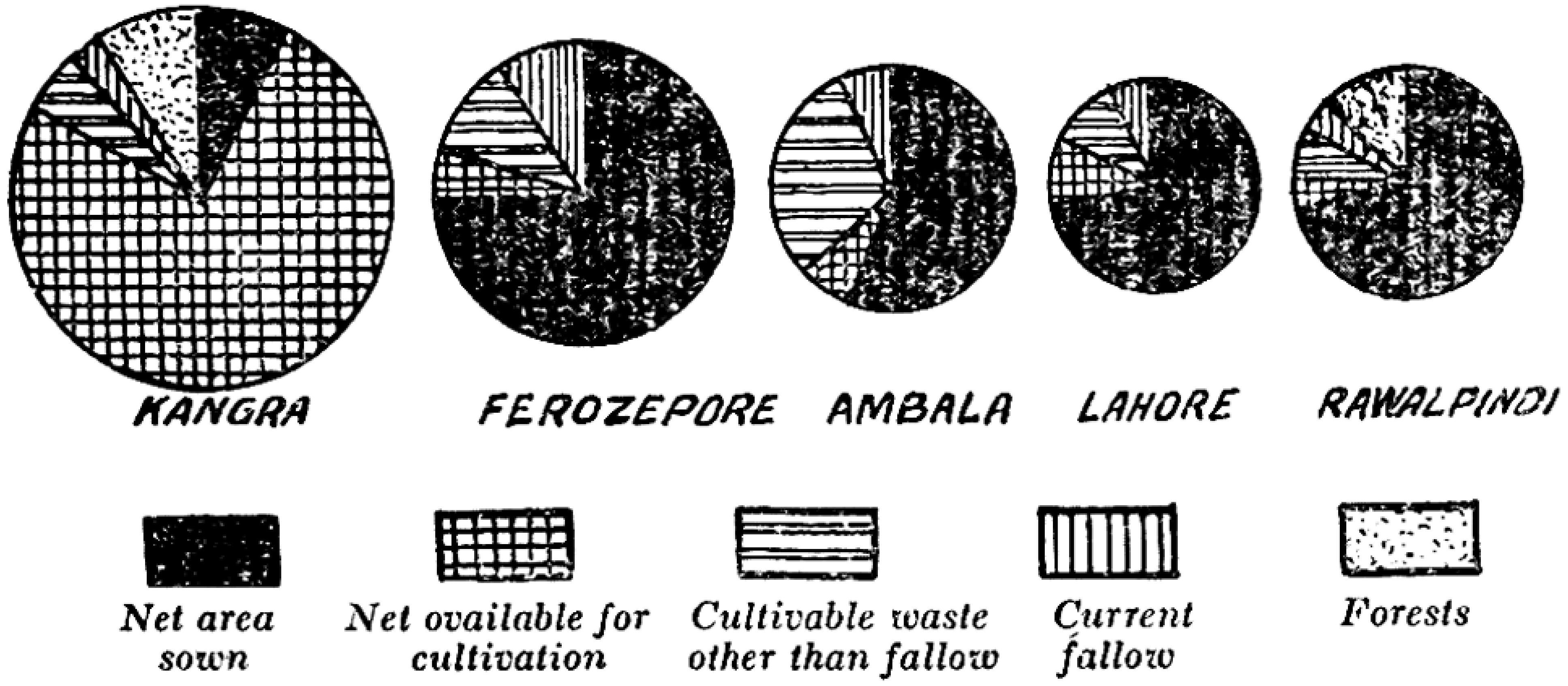


Fig. 22C. Pie Graphs.

1. It is easier to compare lines or bars than it is to compare areas of rectangles or circles.

2. When it is desired to compare sizes which vary in one dimension, lines or bars should always be used, but the method is not suitable when showing great extremes; *i.e.*, the larger figure may require such a long bar that it may be difficult to place it on a page of the drawing book. In such extreme cases, circles may be used, which should be drawn on an area basis.

NOTE.—The data for preparing Statistical and Distributional maps may be had from the following:—

Geographical Statistics by S. J. Elliot & T. S. Goadby.
The India Year Book.

The Statesman's Year Book.
Agricultural Statistics of the Punjab (The Board of Economic Inquiry).
The Crop and Season Report of the Punjab.

EXERCISES

1. (*a*) Describe carefully the data you would require for the construction of agricultural maps of the Punjab.

(*b*) Discuss and illustrate the methods you would adopt to construct a map of the Punjab, showing the distribution of wheat cultivation. (*Punjab Univ., Inter., 1934*)

2. What are the various methods adopted to represent diagrammatically the statistics of production ? Illustrate. (*Punjab Univ., Inter., 1935*)

3. Supposing that you are to present by means of maps and diagrams, an analysis of the statistics of production of Lahore District ; explain briefly how you would collect and use your data, giving specimen maps and diagrams. (*Punjab Univ., Inter., 1936*)

4. You are required to prepare an analysis of the statistics of production of India. Explain how you would collect and use your data, giving specimen maps and diagrams. (*Punjab Univ., Inter., 1937*)

5. You are required to prepare an agricultural survey of Lahore. Explain how you would collect and use your data giving specimen maps and diagrams. (*Punjab Univ., Inter., Suppl. 1937*)

6. What do you understand by the 'Dot System' employed in the preparation of distribution maps ? What is the advantage ? Where does this system fail ? Give examples. (*Punjab Univ., April, 1938*)

7. Represent graphically (by circles) the population of the following towns :—

Town	Persons	Males	Females	Town	Persons	Males	Females
Lahore	400075	253846	146229	Rawalpindi	75767	46086	29681
Amritsar	263210	157823	105387	Multan	108351	60800	47551

(*Punjab Univ., Inter., April, 1941*)

8. Draw a map of India and on it show the trade of the following ports according to the data given :

1934-35 (crores of rupees)

Ports	Total Value of Trade	Value of Imports	Value of Exports
Calcutta ...	90·52	35·32	55·30
Bombay ...	86·54	53·66	32·88
Karachi ...	31·66	15·24	16·42
Madras ...	20·74	12·04	8·70

(*Punjab Univ., Inter., Sept. 1941*)

9. State the function of Statistical Diagrams. Describe the usual types of Statistical Diagrams and discuss the advantages of each. (*Punjab Univ., Inter., April, 1946*)

CHAPTER VII

WEATHER MAPS—I

Before considering the interpretation of weather maps, it is necessary to consider a few important principles and certain terms used in connection with weather maps.

47. Meteorology is that branch of science which treats of the phenomena of the atmosphere as regards weather and climate.

The term *Weather* includes a study of natural conditions such as temperature, sunshine, wind and rain, etc., at any particular place and time. *Climate* is simply average weather.

48. The Atmosphere.—Air is a mixture of gases, chiefly oxygen and nitrogen; carbon dioxide and moisture are also present in varying amounts. The pressure of the atmosphere is measured by means of the barometer, and varies from time to time in any given place, and from place to place at the same time. As we ascend the pressure of the atmosphere decreases. For instance:—

Pressure at sea-level = 30 in. of mercury.
" " 900 ft. = 29 " "
" " 1,130 ft. = 28 " "
" " 16,000 ft. = 15 " "

Hence we see that heights can be estimated by reading the barometer at different altitudes and applying, what is called the *vertical barometric gradient i.e.*, the rate at which the atmospheric pressure falls with altitude. *The barometer falls about one inch for every 900 ft. one rises above sea-level.* The barometer altitudes, however, are not reliable.

Similarly, there is also a falling *temperature gradient* in the atmosphere as we ascend. *The rate is 1°F. for 300 ft.* if the air is dry, but it varies very much from place to place. It is greatly affected by the amount of water vapour in the air up to about 10,000 ft.: above this the gradient is nearly constant up to about 7 miles. Higher up there is either no gradient or a very slight reversed gradient. The upper layer is called the *stratopshere* or *isothermal layer.*

Meteorological observations to be of scientific value must be made on a uniform plan. Observations should be made at fixed hours. The central authority for the collection and publication of results of meteorological observations in India is the Meteorological Office at Poona. Poona is selected as the headquarters, as it is within the Monsoon range and close to more important harbours of India*.

PRESSURE

49. Fortin's Barometer.—This consists of a long glass tube containing mercury and inverted with its lower extremity in a reservoir of mercury. The surface of mercury in the reservoir is always kept at the same level. The lower part can be raised or lowered by means of a screw to bring the level of mercury in the reservoir just into contact with an ivory pin. The divisions on the scale indicate how high the top of the mercury column is above the point of the ivory pin. The instrument is provided with a vernier to ensure accurate reading.

50. A Kew pattern barometer is preferred to Fortin's barometer for general use, as there is no troublesome setting of the surface of mercury in the cistern to an ivory pointer. There is no adjusting screw at the bottom of the cistern; to allow for the rise and fall of the mercury in the cistern, the divisions of the scale are not all equal. Above the reading corresponding to 1,000 mb. the divisions on the scale are less than the true length, and below this point they are greater.

It is supported on gimbals fixed well above the centre of gravity so that it may always hang vertically.

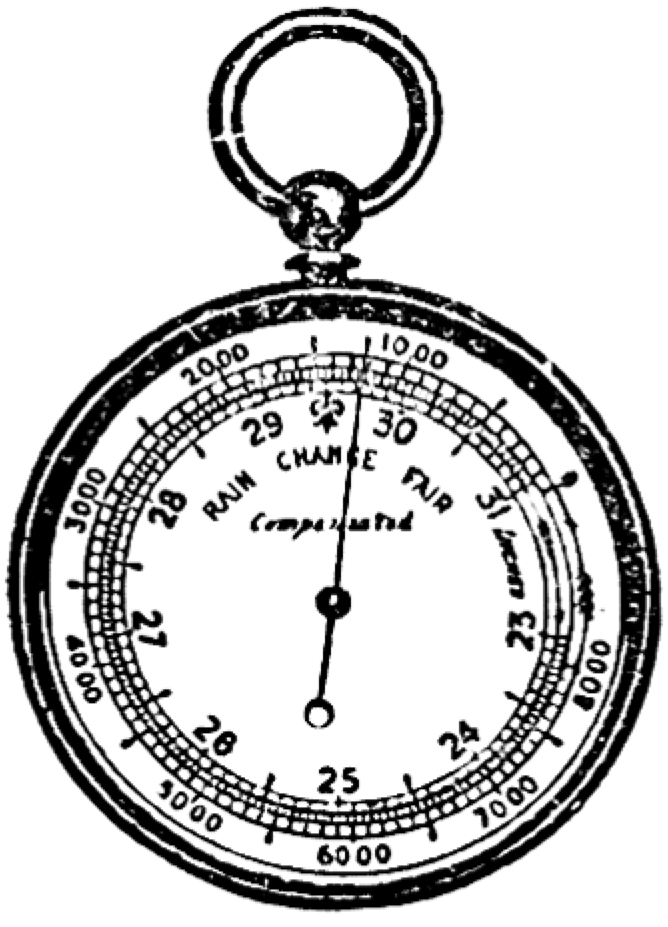


Fig. 24.

51. The Aneriod Barometer.—Fortin's barometer is not easily portable and is not suitable for explorers who travel from place to place. They usually employ an Aneriod barometer. It consists of a shallow metal box with thin flexible lids. The box is partially exhausted of air. An increase in the pressure of air causes the lid to be pushed inwards a little; but if the pressure of air outside the box decreases, the small amount of the air in the box will push the lid slightly outwards. A lever presses against the lid, which takes up the movements

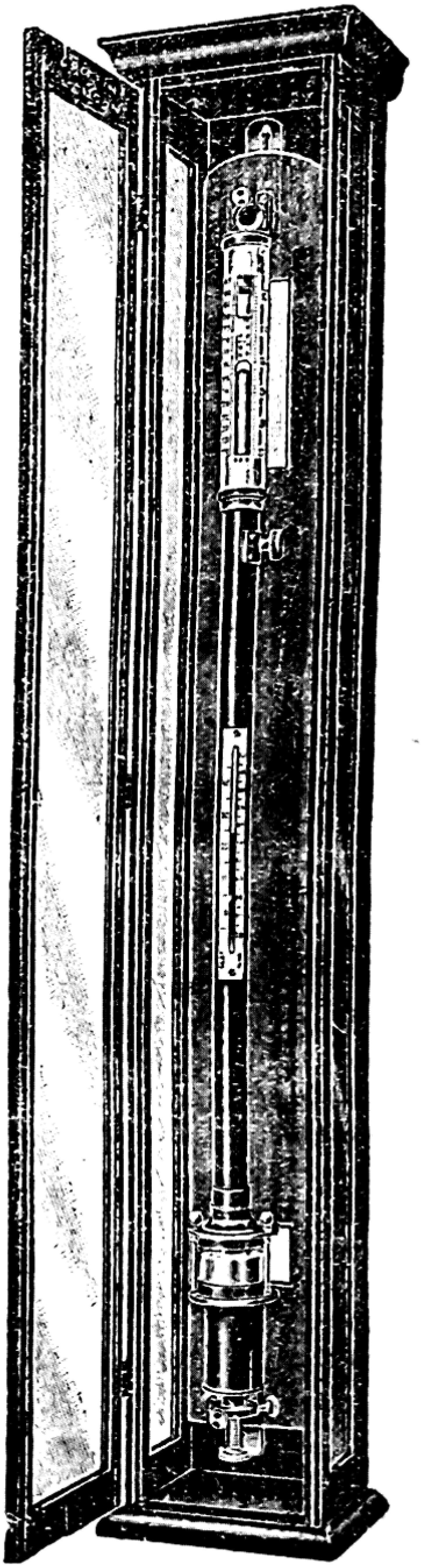


Fig. 23.

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* The student is advised to visit a Meteorological Observatory and get a working knowledge of the instruments described in this section.

of the lid, and communicates them to an index which passes over a scale. (See Fig. 24.

52. A **Barograph** is a self-registering barometer. It consists of several aneroid barometers cemented together and provided with a mechanical device which transmits the movements, and a pointer tracing a line on a revolving drum. See Fig. 25.

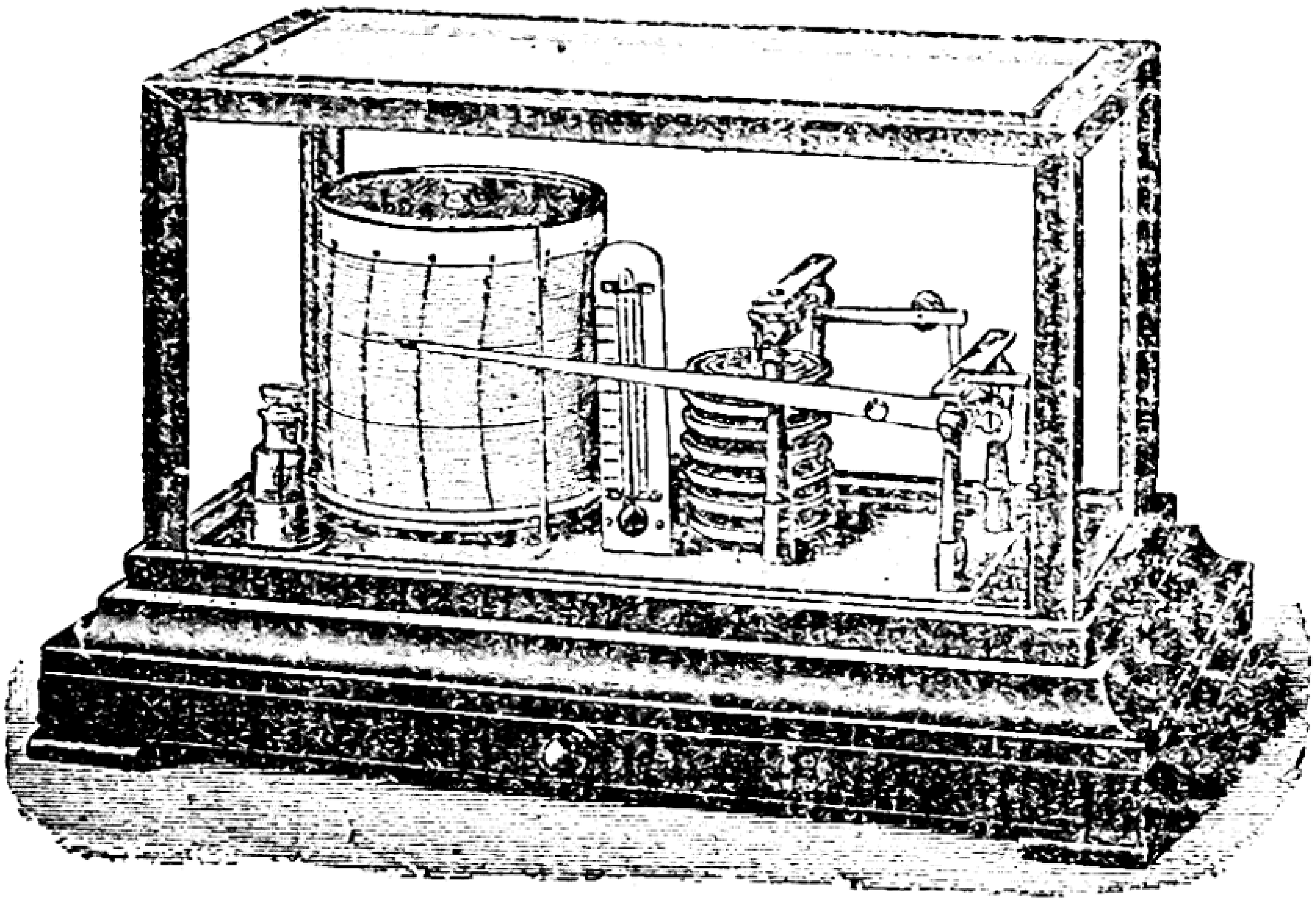


Fig. 25.

53. **Graphic Record of Barometer Readings.**—Study carefully the daily Weather Report of India to be obtained from the Meteorological Office, Poona.

Plot on a squared paper the daily readings of any place for a month. In considering the vertical scale for the graph, notice that the greatest quantity to be shown lies between 28—32 inches and even less. Hence it is best to work suitably with a magnified vertical scale. This of course will hide the remarkable constancy of barometric height.

54. **Isobars.**—Isobars are lines joining together places of the same pressure reduced to sea-level. Isobars do not necessarily follow contour lines. The pressure is observed at many meteorological stations and then the isobars are approximately drawn from the observations after reducing the pressure readings to sea-level. These isobars represent the horizontal pressure gradient, *i.e.*, the rate at which the pressure varies with distance in any direction at the earth's surface. Just as contour lines indicate differences of level and therefore slopes, similarly isobars indicate pressure slopes down which winds tend to blow. The line of steepest pressure-slopes crosses the isobars at right angles. It must be borne in mind that pressure readings at high altitudes must be reduced to sea-level. Say the pressure observed at Dalhousie (height 7,687 ft.) is 19'74 in. The

pressure at sea-level would be 1 inch higher for every 900 ft. of ascent. Hence the correction is +9·62 in. Therefore the pressure plotted on the map would be 19·74 + 9·62 = 29·36 in.

55. Barometric Gradient. The horizontal barometric gradient is the rate of fall of barometric pressure measured at right angles to two isobars. The unit is a fall of 1/100 inch in 15 nautical miles, or about 17 statute miles.

We can determine the strength of winds if we know the barometric gradient. A gradient is moderate when it is not more than 0·01 inch ; it is steep when above 0·02 inch.

56. Units. The primary units of length, mass and time are the centimetre, gramme, and second respectively. The unit of pressure on this system is the *dyme* per square centimetre.

If h cm. = height of a column of mercury,

D = the density of mercury,

and g = the acceleration due to gravity,

then the pressure due to the column $h = hDg$ dynes per sq. cm.

∴ The pressure due to a column of mercury 76 cm. long

$= 76 \times 13{\cdot}6 \times 981 = 1{,}013{,}200$ dynes per sq. cm.

Or approximately one million dynes per sq. cm.

This pressure of one million dynes is known as **Bar.**

The *millibar*, the unit employed for practical purposes by meteorologists is the *thousandth* part of the Bar.

Thus, the normal pressure, *i.e.*, 760 mm. of mercury = 1,013·2 millibars.

or 1000 *mb* = 29·53 inch.

57. Important Terms connected with Weather Maps :—

Cyclones. A cyclone or depression is a region of low pressure surrounded by zones of higher pressure. The isobars are roughly circular or oval with the lowest pressure inside. The weather in a cyclone is very varied. It is often wet and stormy. A cyclone usually moves in the direction of the prevailing winds.

Anticyclones. An anticyclone is a high-pressure area surrounded by belts of low pressure. The weather associated with an anticyclone is usually quiet. There may be slight drizzle but rain seldom falls in a well-marked anticyclone. The sky is usually clear though it is not essential. There may be small clouds in the afternoon which may disappear by evening.

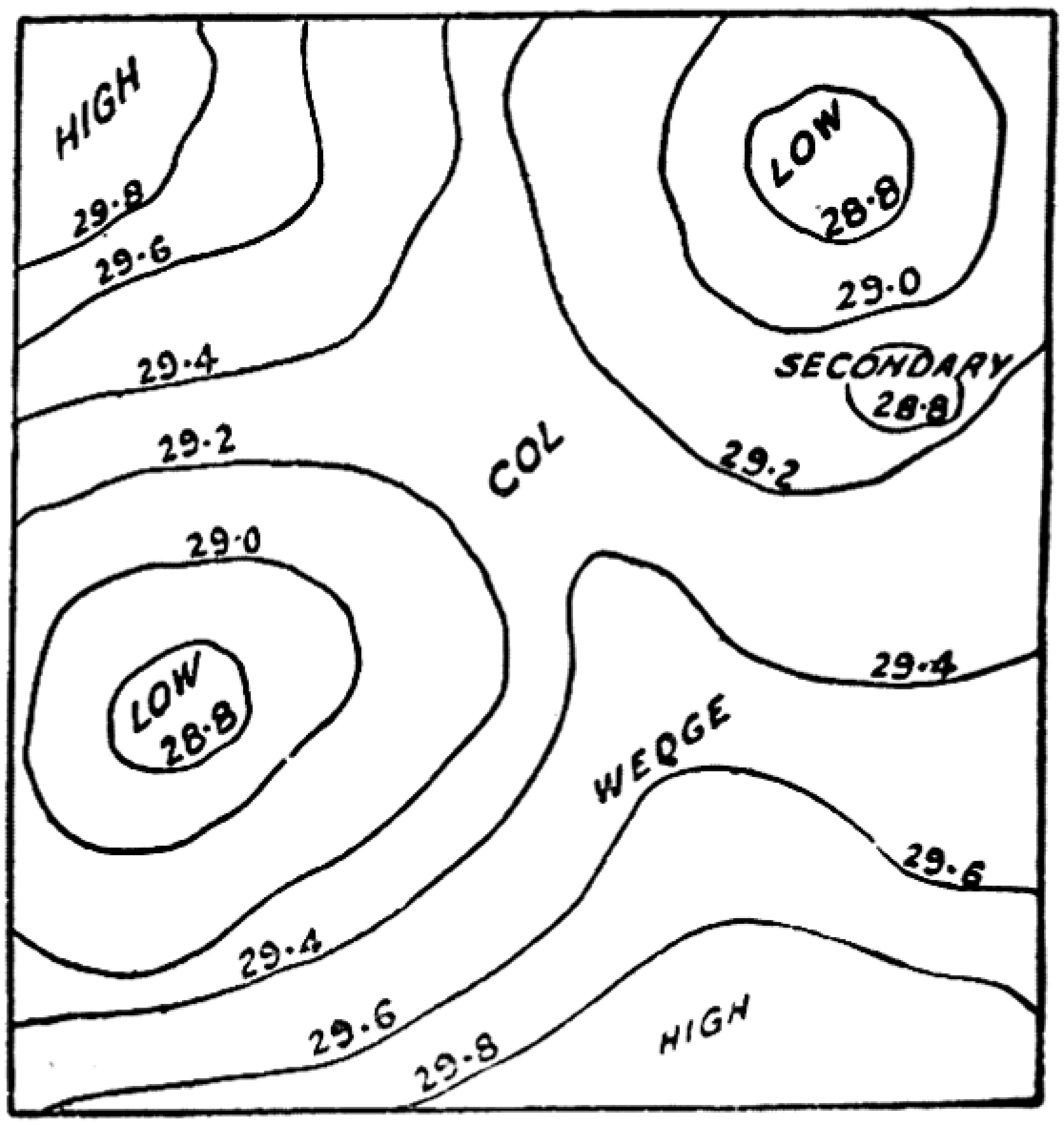


Fig. 26.
(Pressure shown in inches)

Secondary Depression. A secondary depression is a low-pressure system contained in a larger one.

Col. A col is a central region between two high and two low pressure areas. It is a region of calm. The conditions are neither cyclonic nor anti-cyclonic.

The Wedge. A wedge is a region of high pressure where the isobars take the form of an inverted V. It is usually a region of fine weather and good visibility.

WIND

Most of the observations of wind with which meterologists have to deal are estimates of its force made on what is known as the Beaufort Scale, which is reproduced below.

58. The Beaufort Scale of Wind Force :

Beaufort Number	Beaufort's General Description of Wind.	Specification for use on Land, based on observations made at Land Stations.	Mean Velocity Miles per hour.
0	Calm	Calm ; smoke rises vertically. Sea is mirror smooth ...	0
1	Light air	Direction of wind shown by smoke drift ...	2
2	Light breeze	Wind felt on face ; leaves rustle ...	5
3	Gentle breeze	Leaves and small twigs in constant motion ; wind extends light flag ...	10
4	Moderate breeze	Raises dust and loose paper ; small branches are moved ...	15
5	Fresh breeze	Small trees in leaf begin to sway ; crested wavelets on inland waters, ...	21
6	Strong breeze	Large branches in motion ; whistling heard in telegraph wires ...	27
7	Moderate gale	Whole trees in motion ; inconvenience felt when walking against wind ...	35
8	Fresh Gale	Breaks twigs off trees : generally impedes progress	42
9	Strong Gale	Slight structural damage occurs (chimney pots and slates removed) ..	60
10	Whole gale	Considerable structural damage ; trees uprooted. High waves on sea ...	59
11	Storm	Wide-spread damage. Very high waves in sea ...	68
12	Hurricane	Country-side is devastated [Experienced only in Tropical Storms] ...	Above 75

The Beaufort Wind Scale (1936)

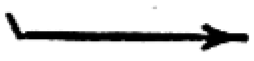
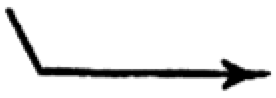
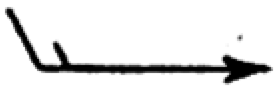
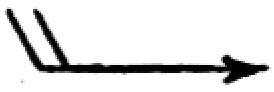
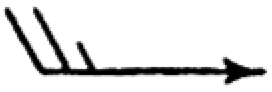
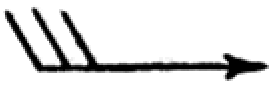
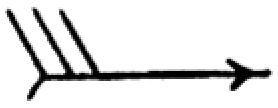
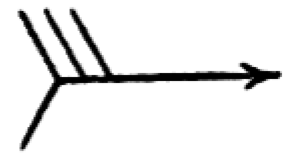
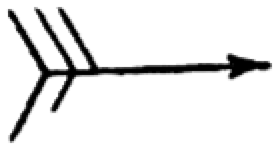
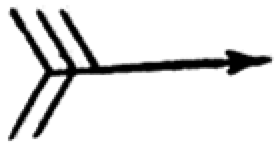
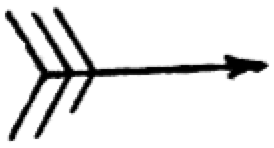
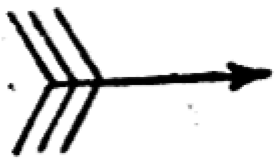
NUMBER	WIND	NOTATION
0.	Calm	⊙
1.	Light air	
2.	Light breeze	
3.	Gentle breeze	
4.	Moderate breeze	
5.	Fresh breeze	
6.	Strong breeze	
7.	Moderate gale	
8.	Fresh gale	
9.	Strong gale	
10.	Whole gale	
11.	Storm	
12.	Hurricane	

Fig. 27.

b	blue sky (not more than quarter covered).
bc	sky partly cloudy (one-half covered).
c	generally cloudy (three-quarters covered).
o	overcast sky.
f	fog.
KQ	line squall.
m	mist
q	squalls.
d	drizzle.
h	hail.
l	lighting.
p	passing showers.
r	rain.
rs	sleet, *i.e.*, rain and snow.
s	snow.
t	thunder.
v	usual visibility.
w	dew.
x	hoar frost.
y	dry air : humidity less than 60 per cent.
z	dust haze ; the turbid atmosphere of dry weather.

59. Weather Symbols :—

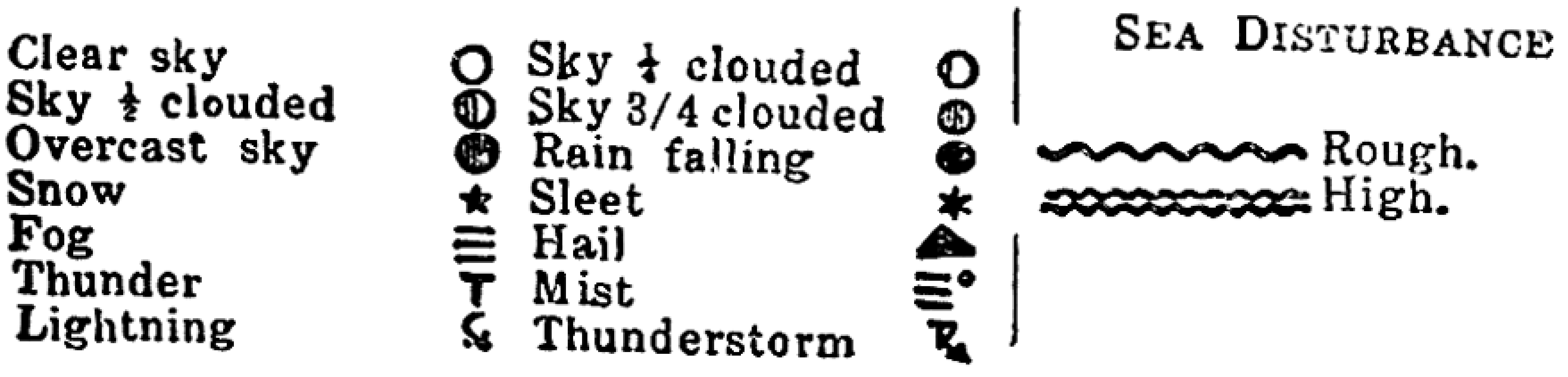


Fig. 28.

Capital letters indicate intensity, suffix$_0$ indicates slight and repetition of letters indicates continuity, thus :—

R=heavy rain, rr=continuous moderate rain, r_0r_0=continuous slight rain.

Barometer—Isobars are drawn for intervals of two millibars.

Wind direction is shown by arrows flying with the wind.

Force on the scale O—12 (as above) is indicated by the number of feathers.

Mean velocity is shown in miles per hour by figures in small circles.

Temperature is given in °F.

60. Anemometer. This is a simple instrument for measuring the force of the wind. In Robinson's cup anemometer, the wind causes the spin of a suitably poised vane, like a windmill spinning in a horizontal plane. The wind speed is measured by counting the number of rotations in a given time. The record gives the run of the wind in a fixed time, say an hour. This instrument is not suited for rapid fluctuations of the wind.

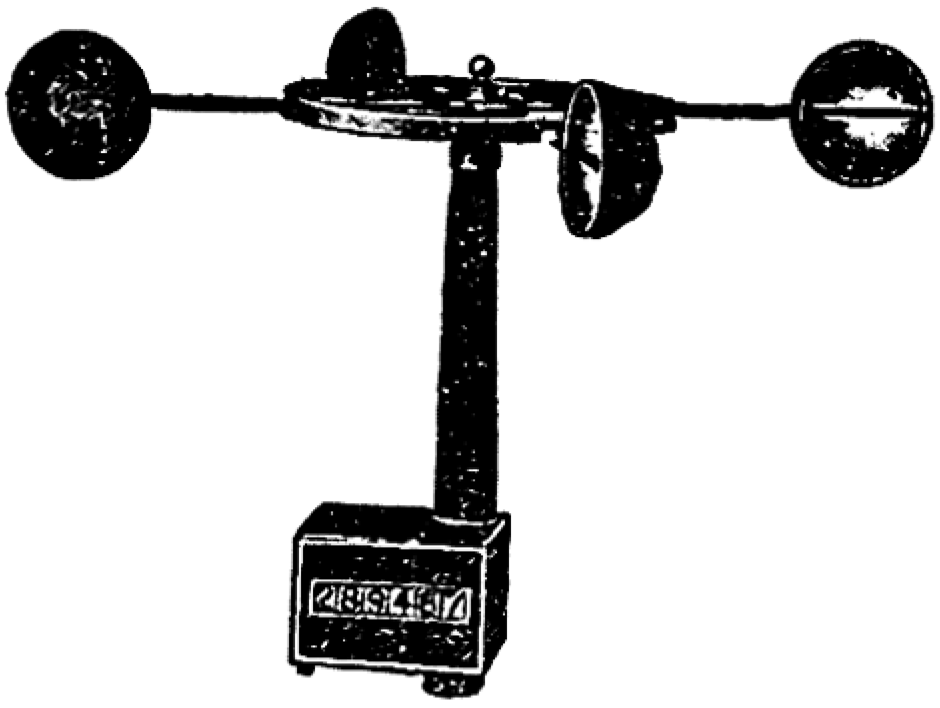


Fig. 29.

* A more useful record is given by the more modern Dine's pressure-tube anemometer which has at many places displaced the cup anemometer. In **Dine's Anemometer** advantage is taken of the fact that the air in blowing over the obstacle produces small differences of pressure on various sides of the obstacle, which are capable of exact measurement, and afford information of the velocity of the wind. The "head" consists of a piece of tube open at one end which end is kept facing the wind by the vane. The wind blowing into the tube produces an excess of pressure within it. There is also a piece of tube placed vertically, pierced by a ring of small holes. The wind blowing on these holes

produces a slight decrease of pressure inside. These differences of pressure are communicated by tubing to the place where the recording of the instrument is placed.

61. **Exploration of the Upper Air.**—The systematic exploration of the upper air is carried out with kites and baloons. Small India-rubber balloons are filled with hydrogen and allowed to drift with the wind. They are watched through the telescope of a theodolite until they either burst or are lost to view. The azimuth and elevation of the theodolite are noted at short intervals.

TEMPERATURE

62. **Temperature.**—From the sun there emanates in every direction what is called *radiant energy*; only a small portion of this energy is intercepted by the earth and manifests itself, in heat, light or as the cause of certain chemical and electrical effects. Air, water and the crust of the earth behave differently towards solar radiation or as it is called *insolation*. When matter is heated it expands; in the case of air and water, this leads to convection currents. The earth represents two kinds of surface to solar radiation :—

(*i*) The rock, which heats up readily, and

(*ii*) Water, which heats up slowly.

The air is scarcely heated directly as air allows practically all the solar rays to pass through it unabsorbed.

Experiment. Take two thermometers. Place one in the sun and hold the other in your hand and move it to and fro. The temperature of the former will be higher than that of the latter.

The lowest layer of the air in contact with the earth is warmed by contact with the earth's surface.

The cause of the varying temperature throughout the year is the alteration of the altitude of the sun, brought about by the inclination of the earth's axis to the plane of the ecliptic. The distance from the earth to the sun has very little to do with the matter.

63. **Temperature of the Air.**—The temperature of the air is ascertained from the reading of a mercury thermometer. The thermometer must give the temperature of the air surrounding it, and must not be exposed to direct sunshine. The thermometers are placed (See Fig. 30) in a screen or box with

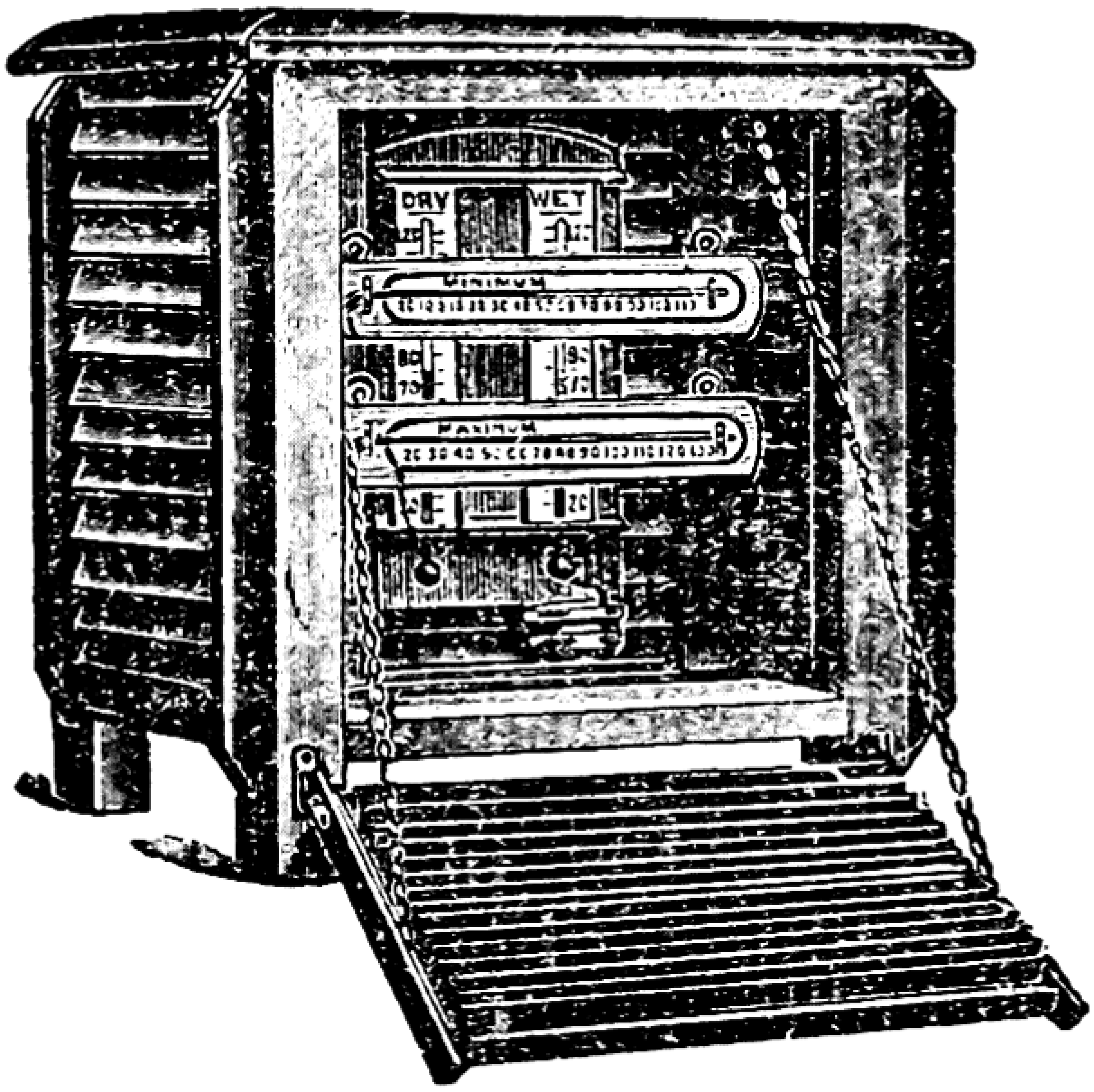


Fig. 30.

louvred sides made of wood and painted white. In certain Meterological Observatories in India the thermometers are placed in huts to secure more ample ventilation.

Temperatures of the upper air are measured by self-registering balloons, *i.e.*, unmanned balloons to which self-registering instruments are attached.

64. Maximum and Minimum Thermometers.—At observing stations in different places the temperature recorded by a thermometer is read two or three times every day. In most observatories, however, two special thermometers are used, one of which records the lowest temperature during the day and night (known as the *minimum thermometer*), and the other which records the highest temperature during the same period (known as the *maximum thermometer*). The instrument is set at 8 a.m. daily.

The *maximum thermometer* is filled with mercury and the tube contains an iron index. The index is pushed forward to the further point reached by the mercury and left there when the mercury recedes again since mercury does not wet iron. The *minimum thermometer* is filled with alcohol in which a glass index is immersed. The index is pulled to the lowest point reached by the alcohol and is left there when the thermometer rises. When the temperature rises the alcohol flows past the index but does not move it. Both thermometers are mounted on the same board (See Fig. 31).

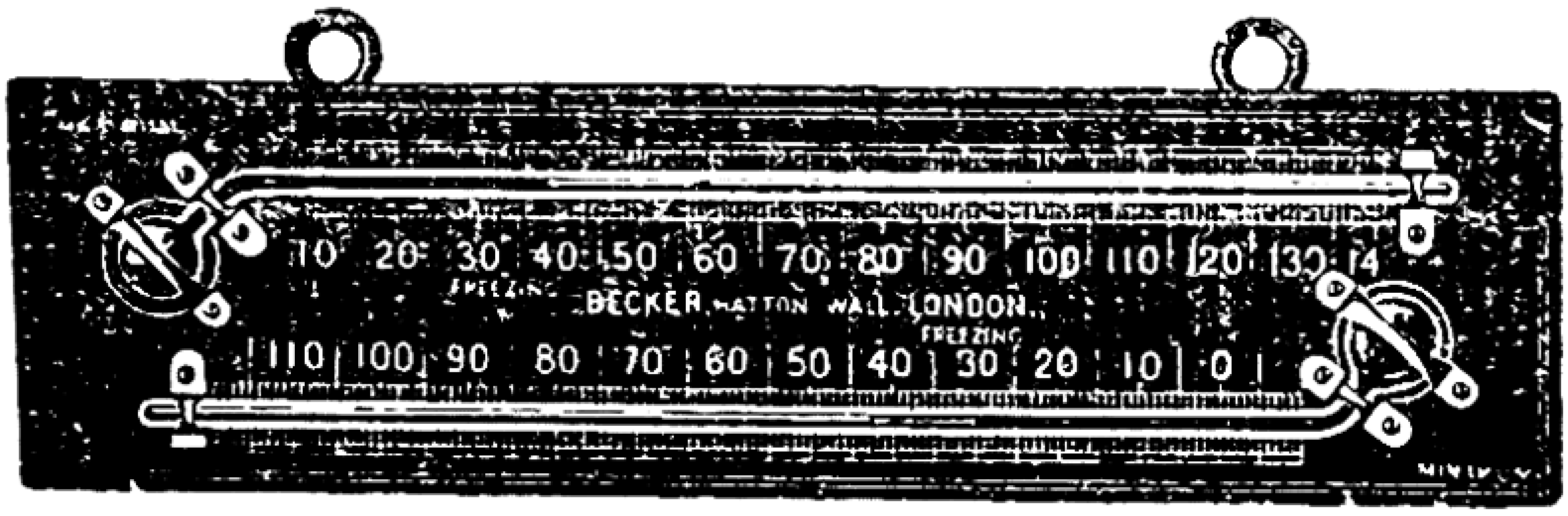
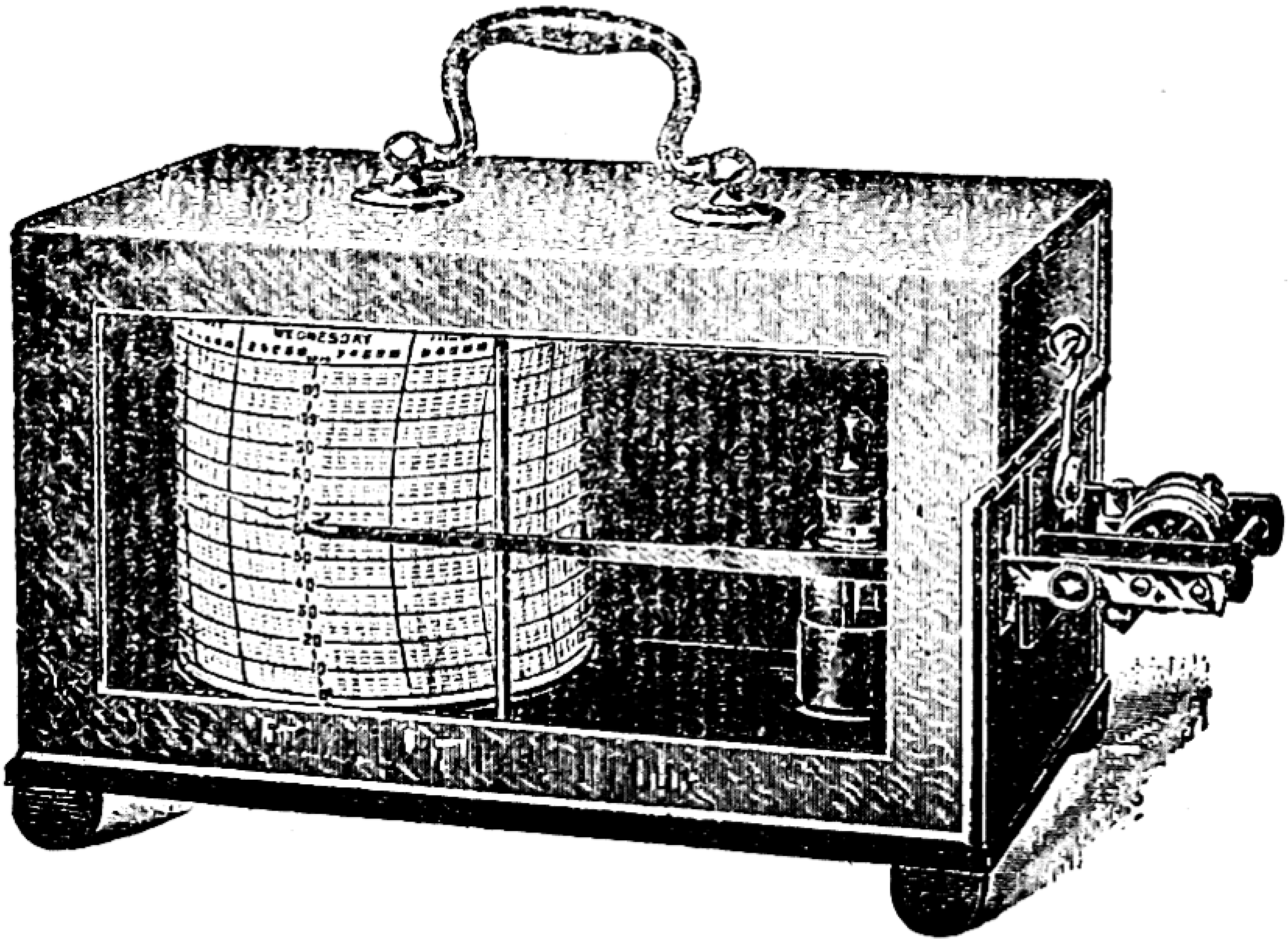


Fig. 31.

65. A Thermograph is a self-registering thermometer (See Fig. 32). A strip composed of two metals with different coefficients of expansion by heat is fixed at one end and connected at the other to a pencil marking on a drum rotated by clock-work. Alterations in temperature cause the pencil to rise or fall, leaving a permanent record.



Fig, 32

66. Mean Temperature.—The mean temperature is obtained from the maximum and minimum temperature, *e.g.*,

Observations made during the 24 hours ending at 8 a.m. on May 26th, 1942.

Station	Max. temp.	Min. temp	Mean temp.
Bombay	94	83	88·5
Calcutta	102	83	92·5
Delhi	106	69	87·5
Karachi	89	82	85·5
Lucknow	108	76	92·0
Madras	103	86	94·5
Nagpur	111	89	100·0
Patna	101	82	91·5
Peshawar	93	69	81·5
Poona	99	74	86·5
Simla	71	50	60·5
Srinagar	66	49	57·5

Mean temperature must be distinguished from *average mean temperature.* If the mean temperatures obtained for a certain day are compared with similar result on the corresponding day of other years, a difference is observed. Average of the mean temperatures of a given day for a number a years is called the average mean temperature for the period of years taken.

67. Isotherms.—An isotherm is a line drawn on a map connecting places of the same mean temperature reduced to sea-level.

The **Annual Range of Temperature** is the *difference* between the mean temperatures of the hottest and coldest months of the year.

EXERCISES

1. Represent graphically the maximum and minimum temperatures at any particular place for a given month. Plot the dates along the abscissa and the temperatures as ordinates. The data can be obtained from the records of Meteorological Office. Mark the maximum temperature by a continuous line and the minimum by a dotted line.

2. Draw a graph of the mean temperature in Ex. 1 and mark it red.

3. Tabulate the mean average temperature for any month (say July) against various stations at which observations are made in India. Draw an outline map of India and mark the places with temperatures reduced to sea-level. Draw lines to represent the isotherms.

N.B.—When observation is made at a high station, a reduction should be made to sea level as explained in § 48.

4. What is an Isobar? Draw various isobaric shapes studied by you in relation to Weather Charts. *(Punjab Univ., Inter. 1937)*

5. Draw a map of India? Show a winter cyclone with its centre at Lahore. Number the isobars and show wind direction by means of signs used on Weather Charts. Briefly describe the weather associated with such a cyclone. *(Punjab Univ., Inter., 1937)*

6. What is an isotherm? How is it drawn? Bring out the principles on which an isothermic map is drawn with special reference to weather maps of India. *(Punjab Univ., Inter., 1938)*

7. What is a cyclone? Give a reasoned account of the weather that may be experienced in the passage of a winter depression across the area in which you live. *(Punjab Univ., Inter., Sept. 1943)*

CHAPTER VIII

WEATHER MAPS—II

68. Clouds.—The study of clouds is a most fascinating one. It appeals equally to the artist and the scientist. Clouds are full of meaning for the army airman. The study of clouds includes the following :—

(*i*) Their form and type ; simple outline and open shading will fully suffice in depicting them.

(*ii*) A knowledge of their altitudes.

(*iii*) Their weather meaning.

(*iv*) The direction from which the cloud comes.

***69. Classification.**—The number of forms that clouds may take is unlimited. The International Classification of clouds consists of 10 main types, which for convenience are arranged according to height above the ground. These heights are for tropical countries and are generally applicable to level country. In mountainous areas, the heights above the ground would be generally lower than those given below :—

A.	*High Clouds*	Height 7—12 Km.
1.	Cirrus	*Ci*
2.	Cirrostratus	*Cs*
3.	Cirrocumulus	*Cc*
A.	*Medium clouds*	Height 3—7 Km.
4.	Alto-stratus	*As*
5.	Alto-cumulus	*Ac*
C.	*Low clouds*	Height up to 4 Km.
6.	Strato-cumulus	*Sc*
7.	Stratus	*St*
8.	Nimbo-stratus	*Ns*

D. *Clouds with Vertical Development*

Upper level : Varriable; may go up to 10—12 Km.

Lower level : 0·5 Km.

9.	Cumulus	*Cu*
10.	Cumulo-nimbus	*Cb*

(**Note** 1 kilometre=3290 feet approx.)

A. High Clouds.

1. *Cirrus.* Light, fleecy, feather-like and fibrous, stretching right across the aky, Composed of ice crystals. Often forecasts an advancing cyclone.

2. *Cirro-stratus.* A thin whitish sheet of cloud often covering the sky.

3. *Cirro-cumulus.* Small globular masses in groups or line. They cast no shadows. Indicate fine weather and are composed of ice crystals.

B. Medium Clouds.

4. *Alto-stratus.* A thick sheet of a grey or bluish colour, sometimes forming a compact mass of dark grey colour.

5. *Alto-cumulus.* Groups of large globular masses of white or grey clouds near the centre. Their edges appear confused.

C. Low Clouds.

6. *Strato-cumulus.* Large globular rolls of dark clouds, frequently extending right over the whole sky, especially in winter.

7. *Stratus.* Low, dense, heavy oloud in horizontal sheets or layers of lifted fog, formed by condensation. Seen at sunset and early morning and usually a fine-weather cloud, indicating quiet settled conditions. Sometimes the cloud forms a gloomy canopy over the whole sky or descends as a fog, requiring a wind to lift it.

8. *Nimbo-stratus.* The "rain cloud." A thick layer of dark clouds, with rugged edges from which steady rain or snow is usually falling.

D. Clouds with-vertical development.

9. *Cumulus.* "Woolpack" clouds. Thick clouds of which the upper surface is dome-shaped and the base is norizontal.

10. *Cumulo-nimbus.* The "storm" or "thunder clouds." Heavy masses of clouds rising in the form of mountains or turrets. Rain, snow or hail are precipitated from the base.

To indicate that a cloud is broken, the qualification *fracto* may be applied to these terms *e.g.*, fracto-cumulus. The Frontispiece gives illustrations of various cloud forms, with their names.

***70. Sunshine Recorder.**—This consists of a sphere of crown glass 4 inches in diameter 3 and lb. in weight, supported on a pedestal in a metal zodiacal frame. It must be fixed in such a position that the sun can shine on it the whole of the time it is above the horizon. A prepared card is inserted in the groove behind the ball. The sun when shining burns away or chars the surface at the points on which its image falls. The card is removed after sunset and a new one inserted.

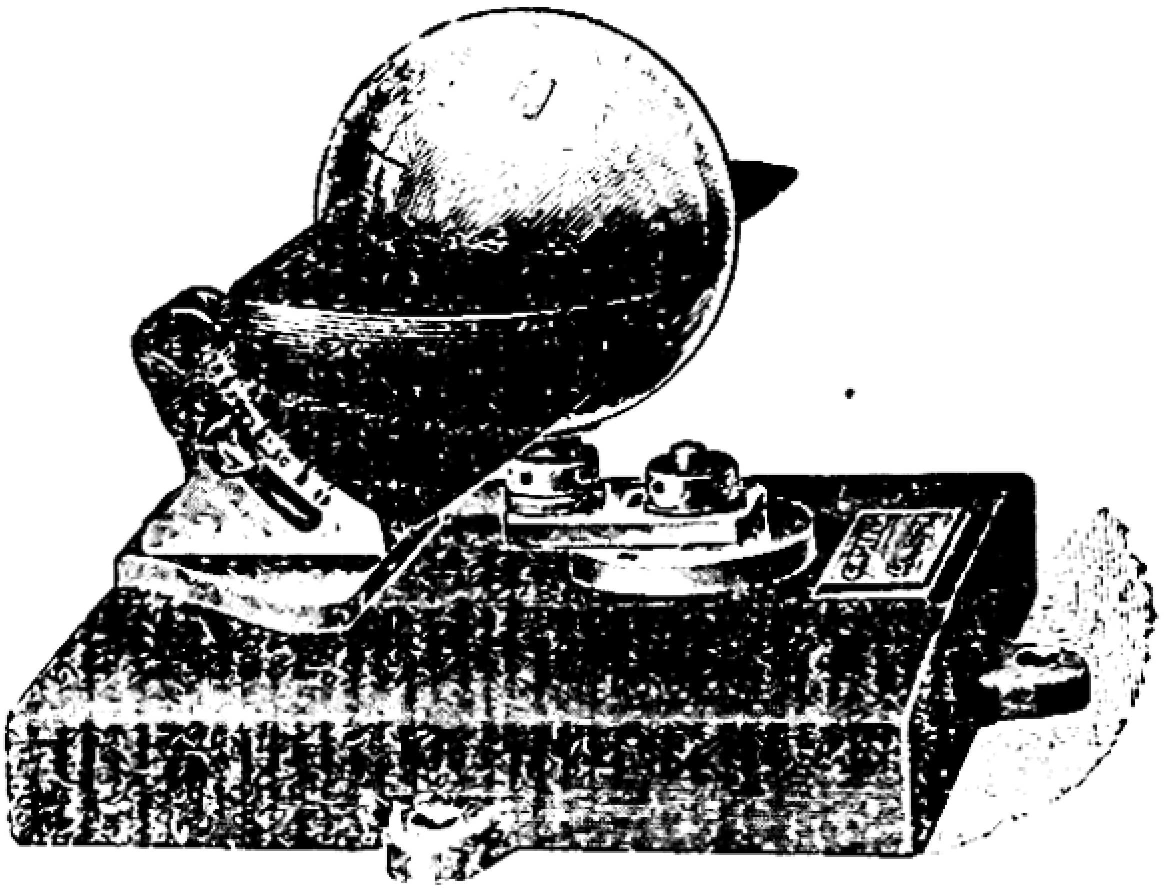


Fig. 33

71. Rainfall.—The amount of rainfall of a place is measured in terms of the depth in inches to which the land would be covered if no rain sank in the ground and if none ran off or was lost by evaporation.

The Rain-gauge The rain-gauge is a simple instrument for measuring the amount of rainfall.

Take a glass funnel and a cylinder of exactly the *same* diameter. Fit the funnel in the cylinder: this will form a rough gauge. Take a small flat-bottomed cylinder and paste a vertical strip of paper *AB* on it. Pour water in the large cylinder till its depth is just 1 inch (measured by the ruler held vertically inside the cylinder). Transfer this water to the narrow cylinder. Draw a line on *AB* at the surface of the water and mark it 1 in. Sub-divide this height into tenths. Note that the graduated cylinder can only be used for the particular gauge for which it is made.

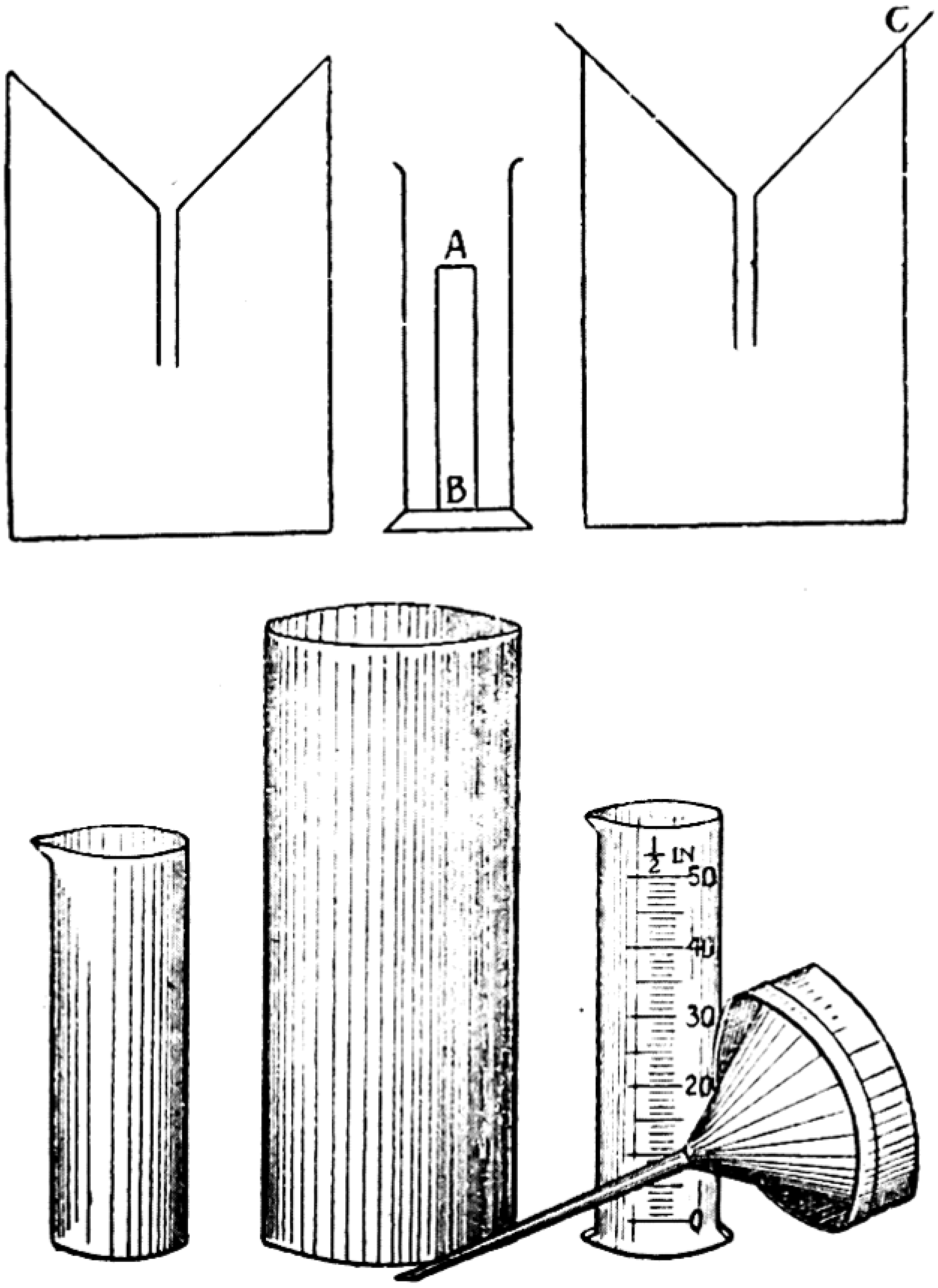


Fig. 34.

The student can make a simple rain-gauge for himself from a jam-jar and a small cylinder. If the funnel is of greater diameter than the jar, the above method will not do. The height in this case must be found by calculation.

*Let A, R, D, be the area, radius and diameter of the funnel and a, r, d, the area, radius and diameter of the cylinder, and let h be the height of water in the cylinder.

Volume of water in large cylinder or jar = Volume of water in small cylinder

$$1 \text{ in} \times A = h \times a$$

$$\therefore \quad h = \frac{A}{a} = \frac{\pi R^2}{\pi r^2} = \frac{R^2}{r^2} = \left(\frac{D}{d}\right)^2$$

Thus $\left(\frac{D}{d}\right)^2$ gives the number of inches that the 1 inch mark must be drawn above the bottom of the cylinder

72. Plotting of Rainfall Statistics.—When the rainfall is measured daily, we often find an abrupt change from day to day. It is generally represented by shaded rectangles, the heights of which stand for the amount of rain (Fig. 35).

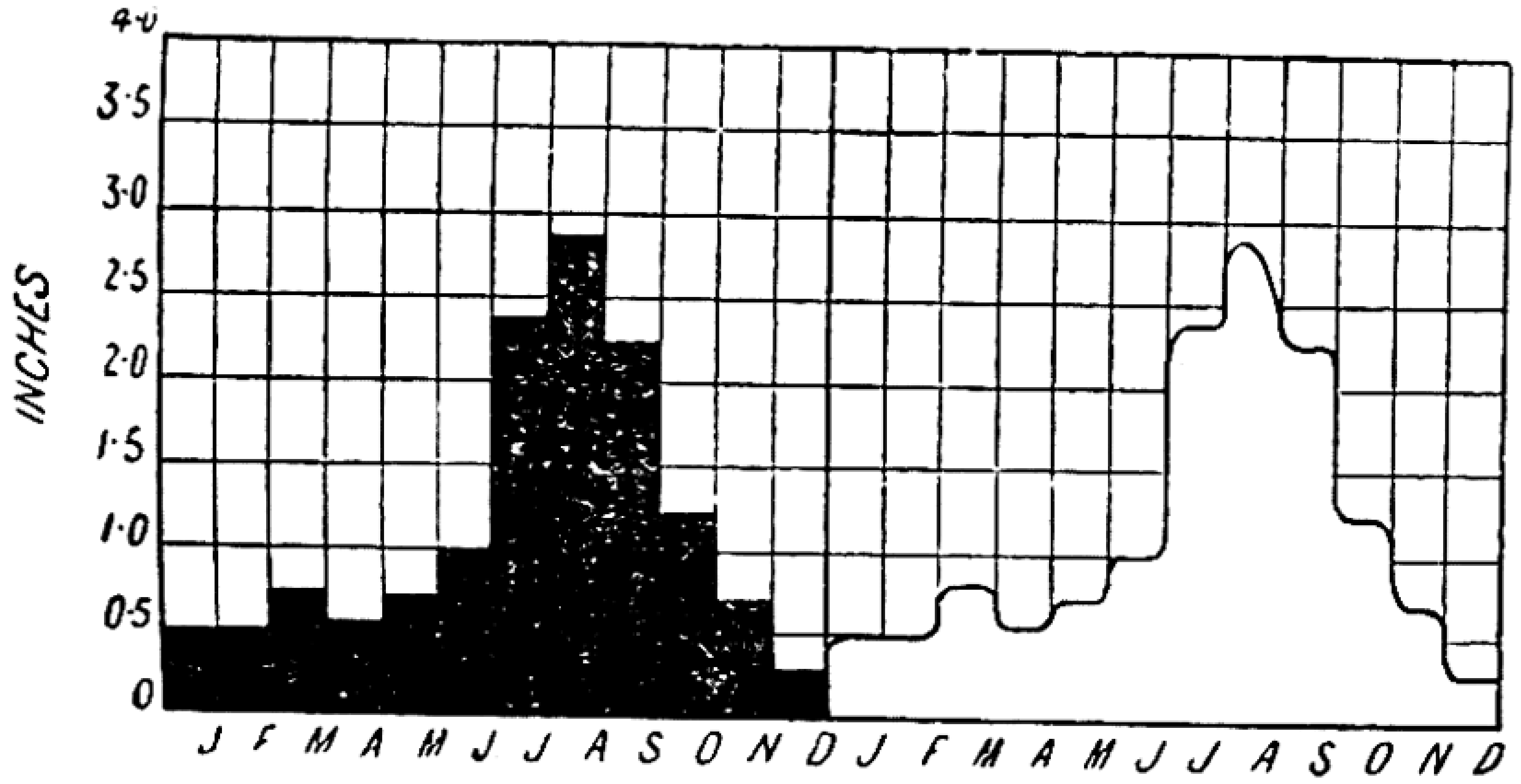


Fig. 35.

Rainfall graphs may be plotted on the same principle as the graph for pressure and temperature, except that the pointe are joined by straight lines and not by smooth curves. This is because temperature and pressure are continuous, while rainfall is a discontinuous phenomenon.

If the rainfalls for all the days of a month are added together, we obtain the *monthly rainfall* of a place ; similarly the *annual rainfall* for the whole year. If we take the average of the rainfall for corresponding months of a number of years, we obtain the *mean monthly rainfall* for that period of time.

Rainfall Maps. Rainfall maps are usually provided with a table of the style of shading to indicate the varying amounts of rainfall.

73. Moisture in the Atmosphere.—Water vapour is always present in the atmosphere in variable amounts. Evaporation is continuously going on from every surface of water even when the weather is cold ; otherwise the *dhobi* would not be able to get his washing dried outside in the air. The rate of evaporation depends upon (*a*) the temperature of the air, and (*b*) the amount of water vapour already present in the air.

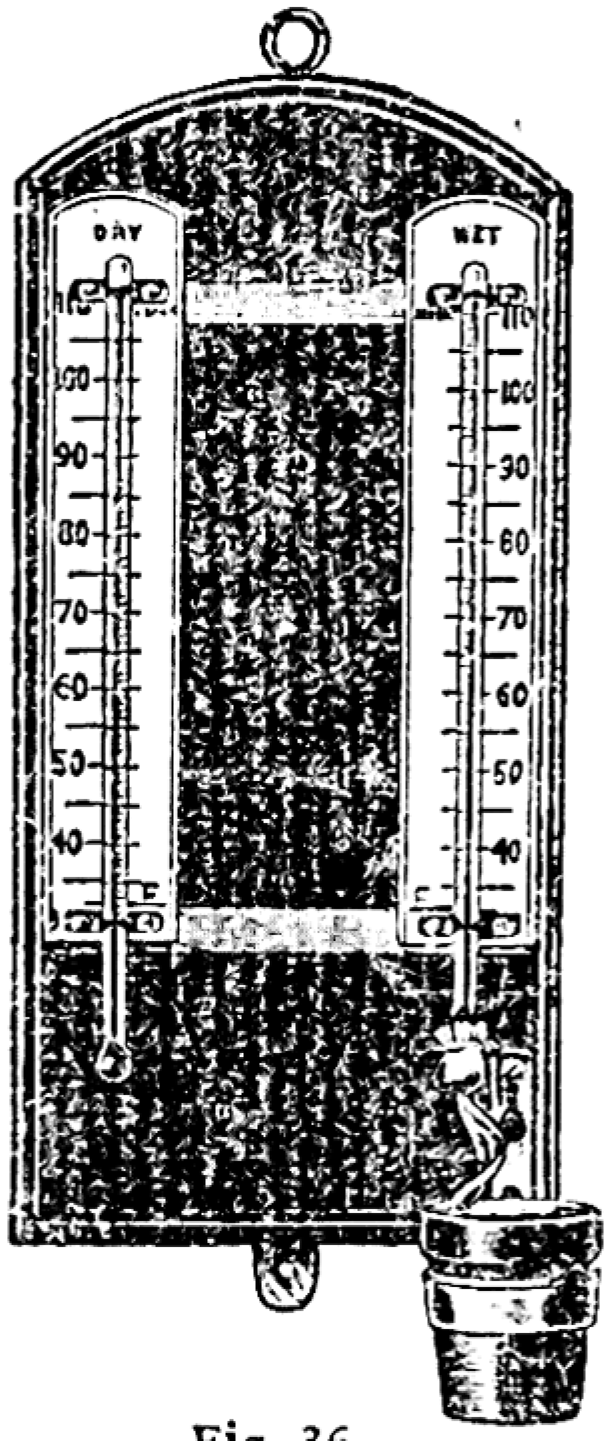


Fig. 36.

When a certain space has taken up all the vapour it can, it is said to be ***saturated.*** If the temperature of the space rises, it can take up more water vapour and thus become ***unsaturated.*** If the temperature falls, the amount of water vapour that the space can hold decreases ; if the space is saturated, some of the vapour will condense. The temperature at which condensation of water vapour to liquid water takes place is called the *dew point.*

74. Wet and Dry Bulb Thermometers.—Take two thermometers precisely alike and fix them side by side on a board. Cover the bulb of one with muslin or a piece of cloth, the outer end of which is dipping in a small beaker, or a tin can containing water. The temperature of the wet bulb thermometer will always be lower than that of the other when evaporation is going on from its surface. Take the readings of the two thermometers. Find by subtraction the difference in themperature between them. This difference determines the saturated or unsaturated state of the atmosphere.

Care should be taken to keep the beaker filled with distilled water. The muslin should be changed once a month. In damp weather the dry bulb thermometer should be wiped a few minutes before observation.

75. Meteorological Records.—The student is now in a position to keep a monthly record of meteorological observations which should be arranged in columns as shown below :

Place............................ ...
Month...............................19
Height above sea-level.........feet.

Date.	Barometer Reading	Wind.	Rainfall in inches	Type of clouds, if any	THERMOMETER			
					Max.	Min.	Wet.	Dry.

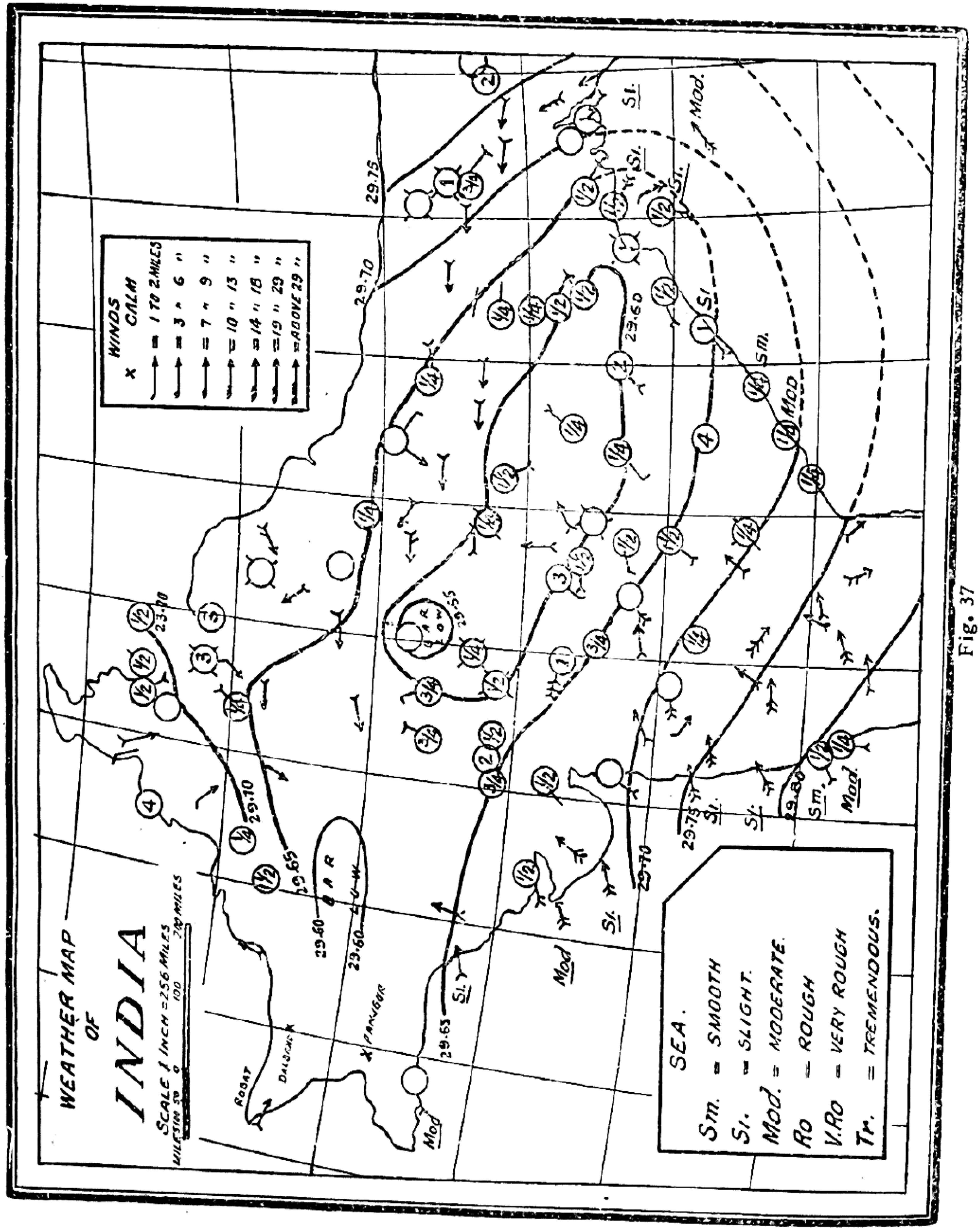

WEATHER MAP OF INDIA
SCALE 1 INCH = 256 MILES
MILES 50 0 100 200 MILES
WINDS
x CALM
= 1 TO 2 MILES
= 3 " 6 "
= 7 " 9 "
= 10 " 13 "
= 14 " 18 "
= 19 " 23 "
= ABOVE 29 "
SEA.
Sm. = SMOOTH
Sl. = SLIGHT.
Mod. = MODERATE.
Ro = ROUGH
V.Ro = VERY ROUGH
Tr. = TREMENDOUS.
BAR LOW
BAR LOW 29.55
ROBAT
DALBANDIN
PANJGUR
29.60
29.65
29.70
29.75
29.80
Sm.
Sl.
Mod.

Fig. 37

76. The Indian Daily Weather Report.—The weather map gives a succinct summary of the conditions over a large area and is based upon observations made at a number of stations and collected together at a central office. The Indian Daily Weather Report can be obtained from the office of the Director General of Observatories at Poona. The weather notations adopted have been explained in the preceding sections. Study the following questions :—

(1) What system of pressure distribution is shown ? Observe if the isobars form a cyclone, anticyclone, a col, wedge or a secondary depression, etc. and note the weather you would expect at places where such formations occur. Study the departure of pressure from the normal.

(2) Where are the strongest winds experienced ? What kind of weather is being experienced there ?

(3) Where is rain falling ? and where is the weather fine ? How do you account for the presence or absence of rain in these places ?

Tabulate the rainfall of a few important stations.

(4) Examine the departure of temperature from the mean.

(5) Study if the sea is smooth or rough etc.

(6) What general inferences may be drawn for the day ?

(7) Study the weather maps for two or three consecutive days ; observe how the pressure system moves and prepare a forecast for the following day.

(8) A useful exercise is to prepare a graph showing the pressure gradient from one place to another, say from Lahore to Madras.

EXERCISES

1. Study the weather map of India for the following dates and record your observations ;

January 30th, March 18th, May 16th
July 15th and 16th, August 18th, September 26th
October 25th and 29th. November 18th, December 11th.

2. Study the weather map of India for June 1st to 4th and prepare a forecast for June 5th.

3. How are storms predicted in India ? Illustrate by a diagram or a chart.

4. Point out the connection between areas of high and of low pressure and the direction of the wind. What influence has the rotation of the earth on winds ? In what direction do winds blow that are most altered in direction thereby ?

5. Analyse a typical weather map to show (*a*) what information can be derived from it ; (*b*) what data would be required for its preparation.

6. Compare any two weather maps showing the weather conditions associated with cyclones and anticyclones (*a*) in winter (*b*) in summer.

7. How are weather forecasts made ? What unforeseen factors may possibly interfere with the forecast ?

8. Examine a map of India, which shows isotherms for January and July ; draw lines of equal annual range of temperature. Comment on any points of special interest.

9. In what respects does an isothermal map and an isobar map (*a*) resemble (*b*) differ from a contoured map ? What adjustment of data is necessary before preparing isothermal and isobaric maps ?

10. The following is the record of the monthly distribution of temperature and rainfall of a place in India. Represent it graphically and locate the place :—

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Temp. (F)	75·3	76·6	79·9	84·1	88·7	88·4	85·7	84·5	83·9	80·8	77·9	75·7
Rainfall	1·1	0·3	0·3	0·6	1·8	2·0	3·8	4·5	4·9	11·2	13·6	5·4

(Punjab Univ., Inter., Supp. 1932 and April, 1945)

11. Describe exactly how the material obtained by the Meteorological Office, Poona, is plotted to form the daily weather map of India. What information can be had from this map? *(Punjab, Univ., Inter., 1934)*

12. Draw a map of India and show—

(*a*) a Bay cyclone (July) with its centre near Calcutta.

(*b*) Number of isobars, and probable areas of cloud and rainfall.

(Punjab, Univ., Inter., 1935)

13. What is a weather chart ? How is it prepared ? What information is to be had from the chart ? *(Punjab, Univ. Inter., 1936 & Suppl. 1937)*

14. Give the principal features of the Indian Daily Weather Report to show your familiarity with it. Where is it published and how is the data collected ? *(Punjab, Univ., Inter., Sept. 1941)*

15. What are the elements of weather ? Study the map provided to you and answer the following questions :—

(*a*) What is the range of pressure ?

(*b*) What is the general direction of isobars on the land and over the Bay of Bengal and why so ?

(*c*) What weather conditions in the north-western part of India are at present found ?

[Map given—June 14, 1941.] *(Punjab, Univ , Inter., 1943)*

16. What is an inch of rain ? Describe the construction and method of use of any type of instrument for measuring it. What special precautions are necessary in the construction and use of a rain-gauge to ensure accuracy ? *(Punjab, Univ., Inter., April 1944)*

CHAPTER IX

MAP PROJECTIONS—I

smooth

77. Introductory.—There are many surfaces which are not plane but they can be unrolled or "developed" into plane surfaces without stretching in any direction provided they are made of thin material, *e.g.*, paper or thin metal sheet. For instance, a cylindrical tube, if cut from end to end, can be laid out flat to form a plane surface. A cone is another surface which can be developed by cutting from its point to its base.

A great majority of curved surfaces cannot be unrolled into planes ; they are known as "undevelopable surfaces." For instance, it is impossible to fit a sheet of paper to the surface of a round ball. The sphere, therefore, is undevelopable.

An ordinary geographic globe (12 in. diameter) represents the reduced earth and its shape is very nearly spherical. We cannot lay a sheet of tracing paper on a globe to fit it closely everywhere without innumerable folds and creases. If the surface of the earth were developable, we would not have had to study map projections. As it is, we have to study different methods used for transferring the lines of latitude and longitude from the globe to a flat sheet of paper. A **Map Projection**, therefore, is a means of representing the lines of latitude and longitude of the globe on a flat sheet of paper. The network of latitudes and longitudes thus formed is called a *graticule*.

As stated above it is impossible to make a correct map of any portion of the globe ; it is, however, possible to maintain certain definite qualities in a projection. These are as follows :—

1. Preservation of area.
2. Preservation of shape.
3. Preservation of scale.
4. Preservation of bearing.
5. Ease of drawing.

The student is familiar with the following properties of a sphere.—

1. That every plane section of a sphere is a circle.

2. That the section through the centre is the largest circle that can be cut from a sphere. It is called a *great circle* ; all other plane sections are called *small circles*.

3. That the small circles get smaller and smaller as the plane of section moves away from the centre of the sphere.

78. Classification.—Various methods of projection may be classified in a general form as follows :

1. Cylindrical Projections,
2. Conical Projections.
3. Zenithal Projections.
4. Conventional and Modified Projections.

(1) *Cylindrical Projections.* In these we may imagine a sheet of paper rolled into a tube-form and placed round a globe.

(2) *Conical Projections.* A sheet of paper rolled up to form a simple cone may be placed on a globe of convenient size. The cone could be placed in many positions, but the normal case, that gives a useful map, is the one in which the apex of the cone lies on the axis of the earth produced.

(3) *Zenithal Projections.* Imagine a source of light at the centre of the globe and assume the globe to be transparent. Place a sheet of paper at the North Pole. It will be found that the meridians pre projected as straight lines and the parallels as circles. The paper may be made to touch the globe at any other point, but in all cases the features of the circle will be projected as shadows. Projections made in this way are called Zenithal or Azimuthal Projections.

(4) *Conventional Projections* include some greatly modified projections. These vary considerably in construction and appearance but are very widely used.

79. Latitude and Longitude.—All places on the earth's surface are defined by parallels and meridians, hence a map cannot be drawn unless these are first plotted. Latitude is defined as the angular distance north or south of the Equator. A *parallel of latitude* is an imaginary line drawn round the Earth parallel to the Equator and at a constant angular distance from it. Only one line of latitude, *i.e.*, the Equator, is a great circle ; all others are small circles.

A *meridian of longitude* is a line passing entirely round the sphere and through the poles. All meridians are great circles.

Parallels and meridians intersect at right angles on the globe.

80. Scale.—It is necessary to consider the scale in the construction of projections. Assume the earth to be a perfect sphere.

The radius of the earth $= 3960$ miles

$= 3960 \times 1760 \times 3 \times 12$ inches

$= 250{,}905{,}600$ inches

Let us take this to be approximately

$= 250{,}000{,}000$ inches.

A globe of 1″ radius is 1/250,000,000th of the size of the earth. Hence for a projection on a scale $= 1/250$M we will take the radius $= 1$ inch and diameter $= 2$ inches.

We may similarly calculate that—

On a scale of 1 : 125,000,000, the radius of the globe = 2 inches.
" 1 : 100,000,000 " " " = 2·5 in.
" 1 : 10,000,000 " " " = 25 in.
" 1 : 1,000,000 " " " = 250 in.

CYLINDRICAL PROJECTIONS

81. In cylindrical projections we assume that the globe is surrounded by a cylinder which just touches it around the Equator or along any other great circle. These projections are very common in atlases. The parallels and meridians are first transferred from the sphere to the cylinder and then the surface of the cylinder is developed so that it becomes a flat sheet of paper. The lines can be transferred in several ways to be described presently, each under its proper name.

There are certain features which are common to all these projections :—

1. The cylinder touches the globe along the Equator or along any great circle therefore, the Equator or the particular great circle could be traced through.

2. It will give a circle on the cylinder parallel to the top and bottom. When the cylinder is unfolded, these circles will become straight lines equal in length to the Equator.

3. The distance between the meridians on the map at all latitudes is the same as that at the Equator.

We thus conclude that—

The meridians will be a series of parallel straight lines at right angles to the Equator and the parallels will be a series of straight lines parallel to the Equator.

***82. The Simple Cylindrical Projection.**—In this, the principle adopted is that the distances from parallel to parallel should be *the same* on the map as they are on the reduced earth or globe. The parallels are drawn at their true distance apart so that the graticule becomes a series of squares.

Construction of the Graticule.—Find the length of a meridian according to the required scale. Divide it truly. Draw the Equator at right angles to the meridian and equal to twice its length. Draw parallels parallel to the Equator and merdians as straight lines perpendicular to the Equator spaced at equal intervals.

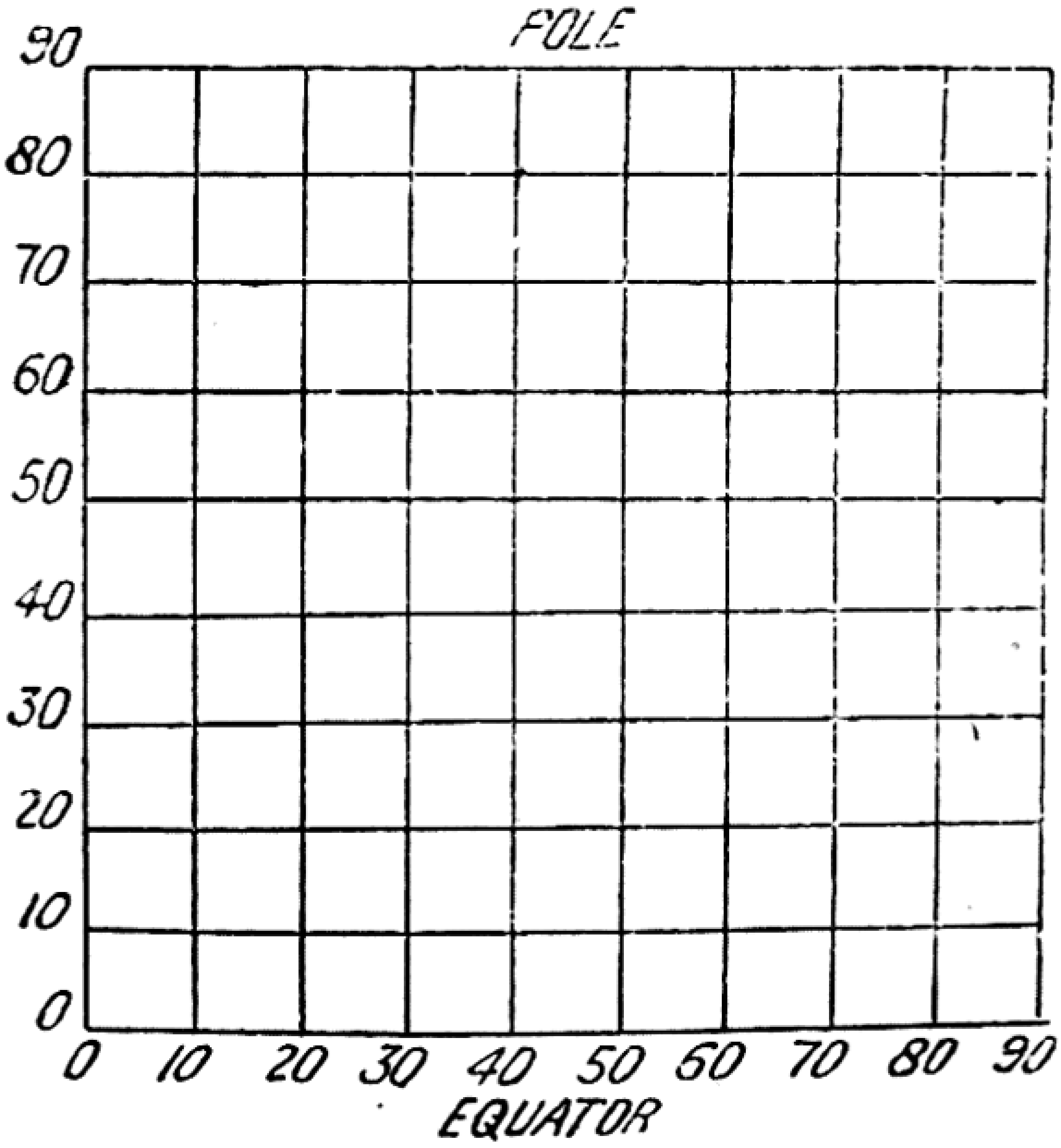


Fig. 38.

This projection is of very little use; it is neither equal-area nor orthomorphic. Its serious defect is that the poles are made of the same size as the Equator.

83. The Cylindrical Equal-Area Projection.—For this projection the meridians and parallels are straight lines and perpendicular to one another, but the area between any two parallels is made equal to the corresponding area on the globe. The Equator is made its true length to scale and is divided as in the simple cylindrical projection. The Poles are again the same length as the Equator.

Construction of the Graticule. Draw to scale a circle to represent the globe, and with a protractor lay off angles at the required intervals of latitude. Then through the points A, B, C,...N, draw lines parallel to the Equator. These are the parallels of latitude. The meridians are spaced at equal distances along the Equator.

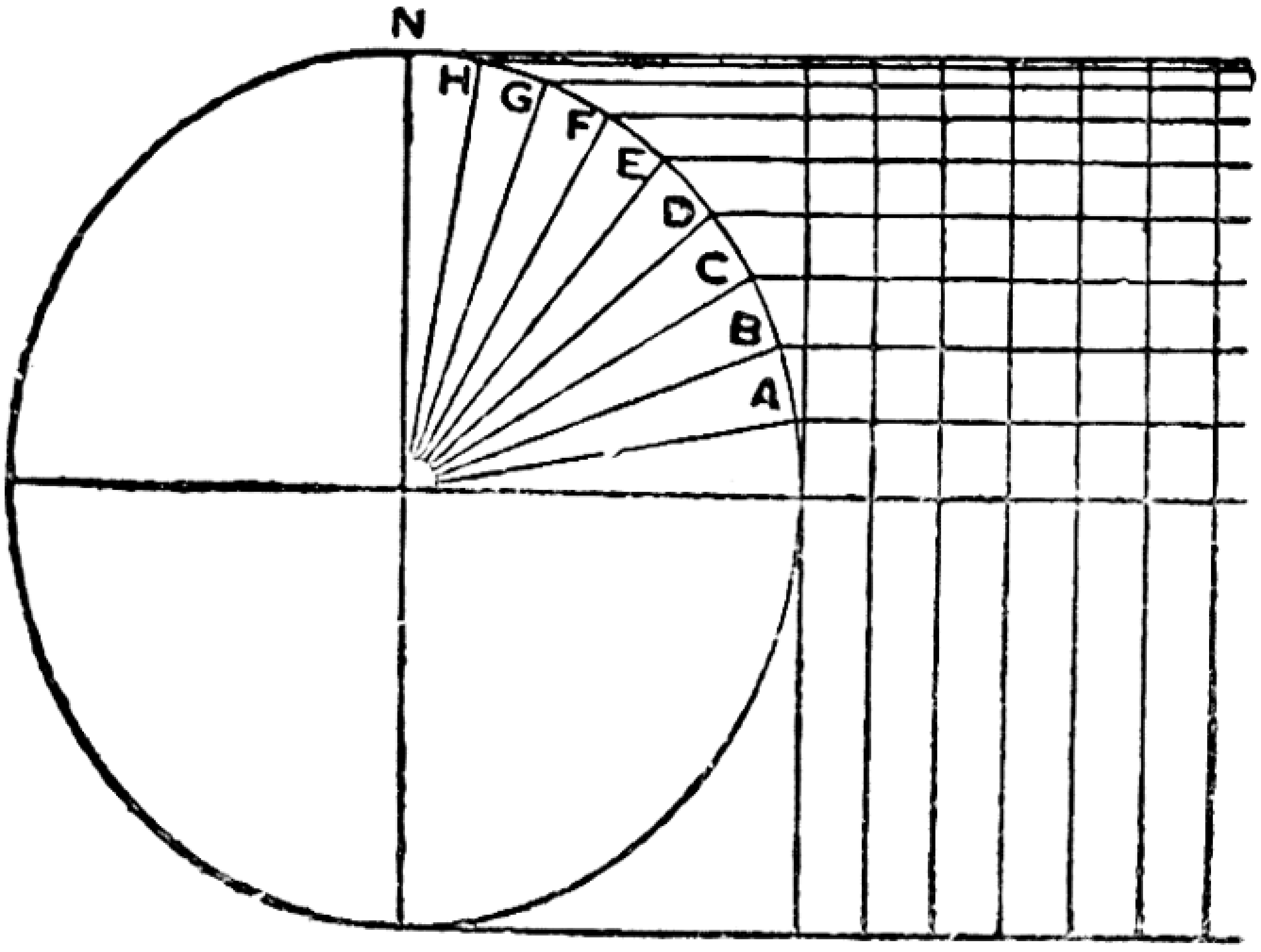


Fig. 39.

As the area of a zone of the sphere is equal to that of the zone of the cylinder of the same height, the areas of the zone on the map are equal to those of the corresponding zones on the sphere. The projection is, therefore, truly *equal area*, and in order to preserve the area, the shape is greatly distorted, the compression in a north and south direction being balanced by an exaggeration in an east and west direction.

It is not a very useful projection and is sometimes used for World maps to show distributions only.

84. Mercator's Projection (or the Cylindrical Orthomorphic Projection).—This is the best known of all projections. It is used for navigation purposes and also in nearly all atlases for maps of the world. Its chief defect is the misleading appearance of the polar areas. A cylindrical projection is orthomorphic when it has the same scale in two directions at right angles at all latitudes. We must, therefore, enlarge the scale along the meridian at each point in the same ratio as it is enlarged along the parallel.

In Fig. 40 (*i*) let us suppose the side of the square is equal to two inches. Its area=4 sq. inches. Point C is due north-east of A.

But if one of the sides is doubled and the other side halved as shown in Fig. 40 (*ii*), where AD is doubled and AB is halved, the area of this rectangle remains the same as that of the original square, *i.e.*, 4 sq. inches but point C is no longer north-east of A.

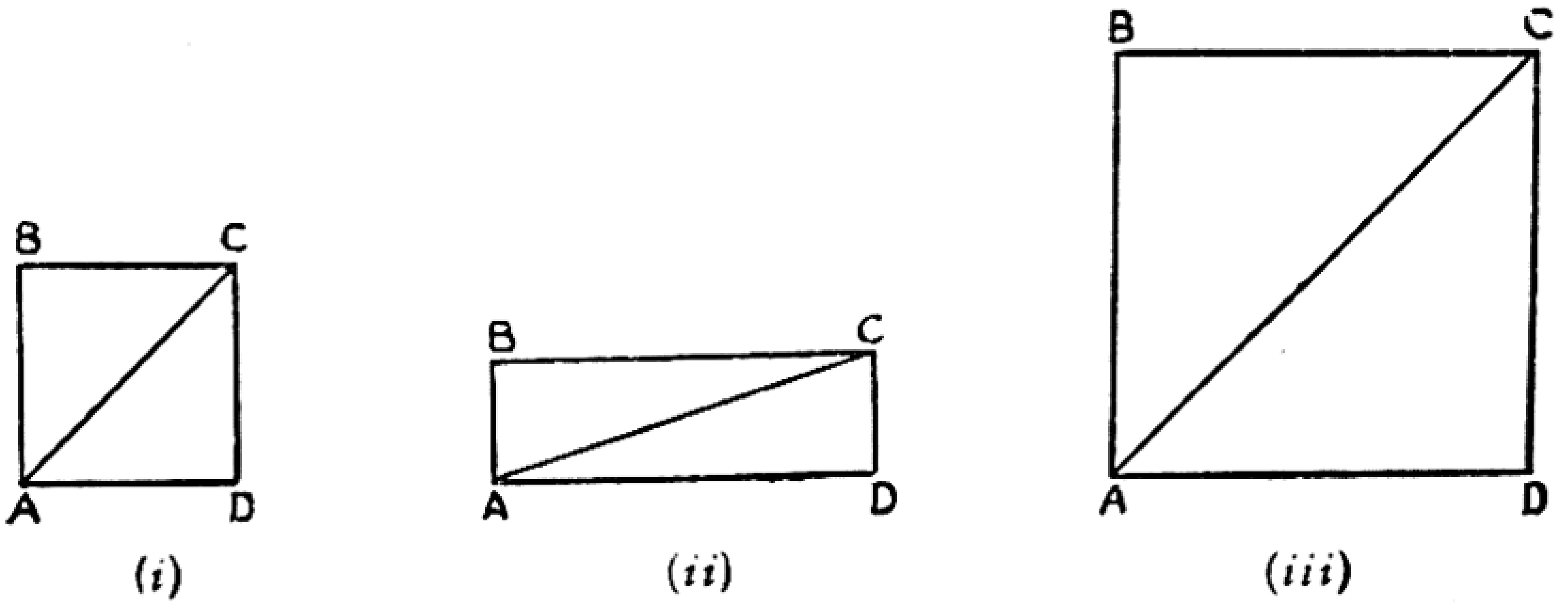


Fig. 40.

If, however, both the sides are doubled, we get a square as shown in Fig. 40 (iii), whose area is four times the area of the original square, *i.e.*, 16 sq. inches, but point C is again due north-east of A.

The parallel of 60° is nearly half the circumference of the Equator. For instance, if the latitude scale along 60° is doubled, we must double the meridian scale also ; a square of 1 mile side will at latitude 60° appear to be a square of 2 miles side, with an apparent area of 4 sq. miles. Hence its chief *defect* is that the scales are correct only near the Equator in either direction ; in high latitudes areas are greatly enlarged. The shape of areas is magnified but *not* distorted. The projection is therefore orthomorphic. South America is nine or ten times bigger than Greenland, whereas on this projection Greenland appears to be bigger than South America.

The great *merit* of Mercator lies in its use for purposes of navigation. As the meridians and parallels are straight lines at right angles, any straight line drawn in any direction on a Mercator chart crosses all parallels at a constant angle. Such a line is called a *rhumb line* or a *loxodrome*. A straight line crossing meridians has a constant bearing as the meridians all run true North and South. [A straight line drawn between two places on any *other* cylindrical projection cuts all meridians at the same angle but it is not a loxodrome.] The loxodrome is not a great circle ; a great circle on Mercator will be a curved line. For "great circle sailing" the bearing must be altered for each day's run, so as to approximate to the great circle course.

Mercator's projection is also used for charts of ocean currents and other cases where it is important that *directions* should be readily seen.

Construction of the Graticule. Draw the equator according to scale, and divide it equally into 9 or 18 parts or any other convenient number. Erect perpendiculars from the points of division : these will give us the meridians, which are equidistant vertical straight lines correctly spaced.

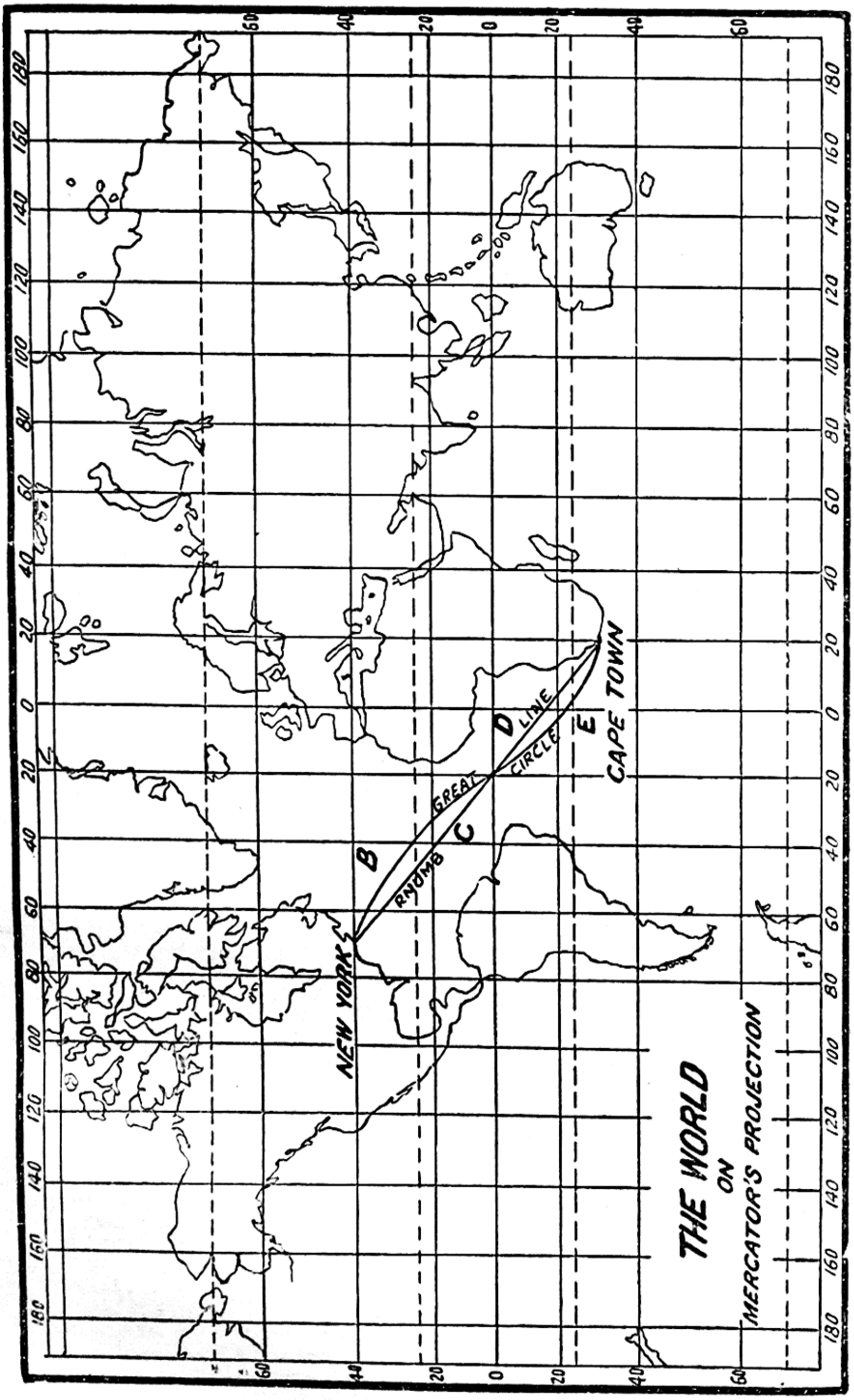

THE WORLD
ON
MERCATOR'S PROJECTION
NEW YORK
CAPE TOWN
GREAT CIRCLE
RHUMB LINE
B
C
D
E

Fig. 41.

The parallels are drawn with the help of the following table :—

Latitude	Distance of parallel from the equator in terms of r (radius of the globe to scale)	Latitude scale in terms of the scale at the Equator.
0	—	1·00
10°	0·175 r	1·01
20°	0·356 r	1·06
30°	0·549 r	1·15
40°	0·763 r	1·30
50°	1·011 r	1·52
60°	1·317 r	2·00
70°	1·733 r	2·92
80°	2·436 r	5·76
90°	∞	∝

Column 2. If the radius of the reduced globe is 2″ on a scale of 1/125,000,000, the 10° parallel will be drawn at a distance of 0·175×2 inches from the equator ;

20° parallel at a distance of 0·356×2 inches from the Equator

and so on.

Column 3. If the distance between meridians 10° apart at the equator is 1″, the distance of 10° parallel will be 1″ from the equator ; the distance between 10° and 20° parallel will be 1·01 inches and so on.

85. Great Circle Sailing.—A ship which sails in the same direction by rhumb line is not taking the shortest course unless it is sailing due north or south or along the equator. It if is sailing due east or west along any other parallel of latitude it is not sailing in a straight line, *i.e.*, it is not taking the shortest course.

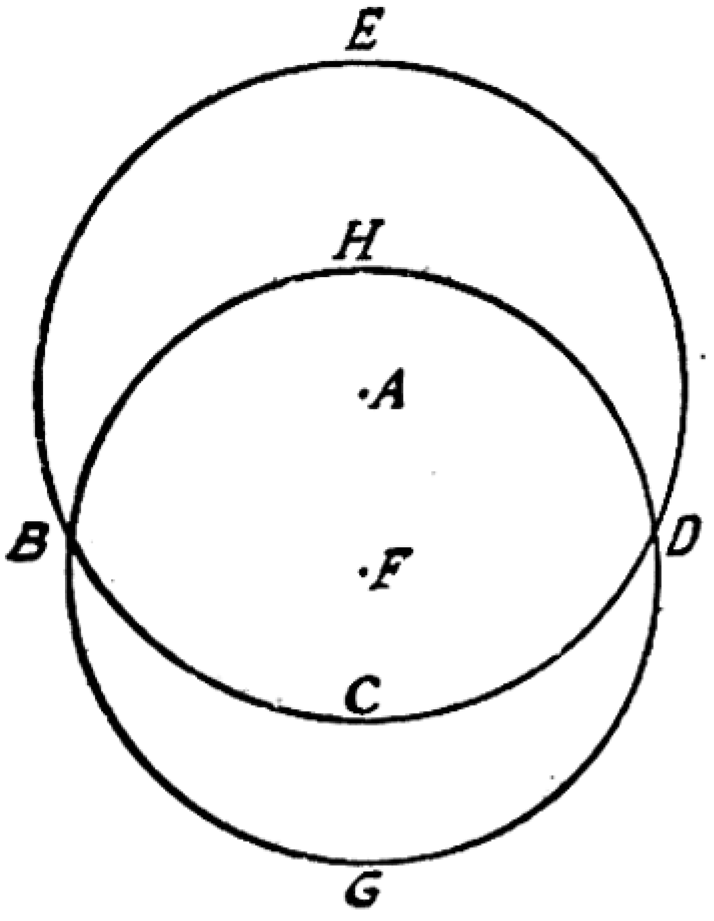


Fig. 42.

Place a string on a globe passing through Tokio and San Francisco, keeping the string loose along the parallel. Now hold one end of the string and draw it taut so that it still passes through the same points. The middle part of the string will move northwards. Repeat with places north and south of equator, *e.g.*, New York and Cape Town. The course marked by the string when taut is part of the great circle passing through these points.

The above may be illustrated graphically as follows :—

With centre A draw a circle BCDE ; now with centre F and radius less than AB draw a circle BGDH. The two circles have a common chord BD. The arc BCD, which is the arc of the greater circle, is obviously smaller than BGD, the arc of the smaller circle.

86. Summary.—The chief *merits* of Mercator's projection are :—

1. It shows direction accurately, hence it is useful for navigation on the sea and in the air, and for showing direction of winds, ocean currents, etc.

2. The shape of the land masses is preserved, *i.e.*, it is orthomorphic.

3. It is extremely simple to construct from tables. All we have to do is to draw straight lines at their correct distances apart.

The chief *defect* is :—

The areas in higher latitudes are very much exaggerated, *e.g.*, Alaska is $\frac{1}{8}$th of the area of U.S.A. but on this projection, it is shown to be of approximately the same size as U.S.A. Hence it is not an equal-area projection and cannot be used for distributions etc.

CONICAL PROJECTIONS

87. Conical Projections.—This group includes a large number of projections, several of which are in common use in atlases. As a class, they are suitable for maps of countries in temperate latitudes which do not have a great extent in latitude.

The modifications which may be made are similar to those which are made in the case of cylindrical projections, *i.e.*, they may be equal-area conicals or orthomorphic conicals.

Let us suppose that a cone of paper is placed over a globe so that it touches it along any chosen parallel. When the cone is developed, the arc of the sector will be of the same length as the parallel to which it was tangent on the globe. Such a parallel is called a *Standard Parallel.*

88. The Simple Conical Projection with one Standard Parallel.—In the simple conic the pole of the cone is vertically above the pole of the globe and thus the globe and the cone coincide along a parallel of latitude, which is the standard parallel and is divided truly. A central meridian is drawn to represent the meridian which actually runs through the centre of the country to be mapped. The parallels are spaced along it at their true distance apart, reduction being made for scale.

Construction of the Graticule.—Describe a circle AEDF representing the globe on the required scale. Choose the standard parallel along the point Q. Draw the Equator AD and the polar axis EF. Produce the polar axis FE to P. At Q draw a tangent meeting FE produced in P. Make the angle BCA=10°. With C as centre and AB as radius describe an arc of a circle. Join QC, the radius. Draw LN $\perp$ CE. Then LN will give us the divisions on the standard parallel, and AB will give approximate divisions along the central meridian.

With P′ as centre and PQ as radius describe an arc of a circle SMS′, which will be the standard parallel. Draw any line P′M as the central meridian. Mark off on P′M (working outwards from M) divisions equal to AB. Mark off along SMS′ divisions equal to LN. With P′ as centre and the divisions along PM as radii describe arcs of circles. Join P′ with divisions on the standard parallel SMS′.

This approximate method is very nearly accurate. The error lies in assuming that AB is a straight line, which matters little in small scales. Any parallel of latitude may be taken as the standard parallel provided it is the central parallel of the area to be projected.

This projection, is much used for small countries which have no great extent in latitude, *e.g.*, Ireland and Denmark.

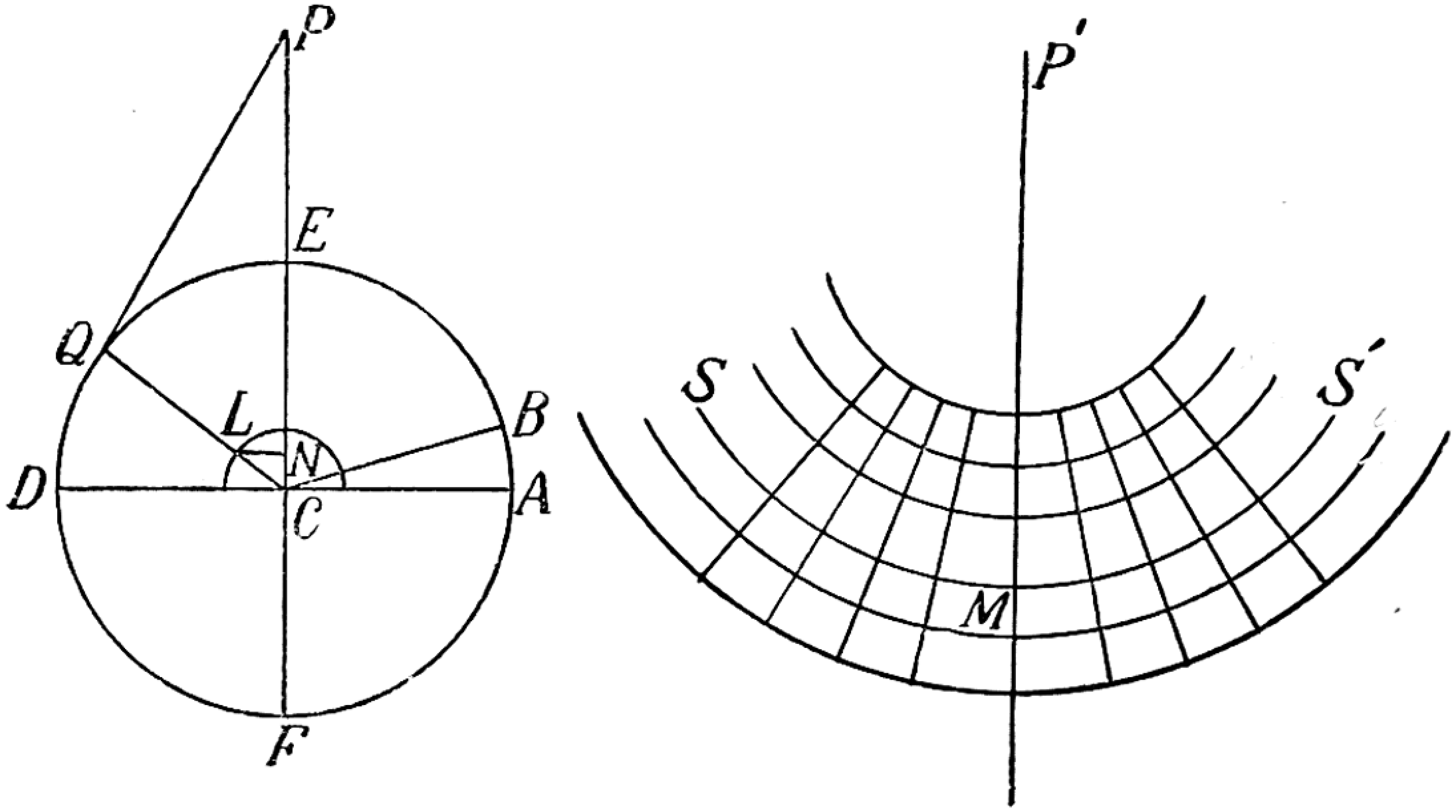


Fig. 43.

The scale is correct on the standard parallel and along the central meridian. The other meridians are radii of a series of concentric circles ; the scales along them is also correct, *i.e.*, the distance from P′ to the parallel corresponds to the distance on the globe. The scale along the other parallel is too great.

The chief *merit* of this projection is that it is a compromise between an orthomorphic projection and an equal-area projection. The distortion for small areas is small. It can be used for general maps of countries in the Temperate zone.

Its chief *defect* is that distortion occurs both north and south of the standard parallel and increases as the distance from the parallel increases.

89. **The Polyconic Projection.**—The basic idea underlying the Polyconic Projection may be arrived at as follows : Divide the Earth's surface into narrow belts of latitude ; draw a strip of a tangent cone to each of them ; project upon the tangent cone the surface of the globe from the centre. Every parallel belt has its own radius.

The Polyconic is used in Geological survey sheets.

A modification of the Polyconic is used for the **International map on a scale of one to one million (1/1,000,000)**, each sheet of which covers 4 degrees of latitude and 6 degrees of longitude. The 1/M Survey Sheets of India cover 4 degrees of latitude and 4 degrees of longitude.

The advantage of this modification lies in its small scale-error which is less than 1/1300 on each sheet. It is possible to fit together one sheet to another either in north-south or east-west direction. Nine adjacent sheets may be fitted together with only a slight amount of stretching.

EXERCISES

1. How would you recognize (*a*) a Mercator Projection, (*b*) a Conical Projection, (*c*) a Cylindrical Equal-area Projection ?

2. Why may a map of the world on Mercator projection be suitable for showing distribution of rubber but not that of wheat ?

3. What projection would you use to show the air-mail route from England to India ? Give reasons for your answer.

4. Say why you consider the following projections unsuitable :

(*a*) Mercator for Canada and Siberia ;

(*b*) Simple conic wtih one standard parallel for South America.

5. (*a*) Explain the relative advantages and disadvantages of conical and cylindrical projections.

(*b*) Show how Mercator's projection is helpful to a mariner.

(*Punjab Univ., Inter., Supp. 1932*)

6. What class of projections are generally used for maps of the equatorial regions ? What is the principle underlying Mercator's Projection ? What are its advantages ?

(*Punjab Univ., Inter., 1933*)

7. Draw a net of parallels and meridians for every 30° on the Cylindrical Equal-area Projection for the reduced Earth of two inches radius. (*Punjab Univ., Inter., 1933*)

8. Draw the net for a simple Conical projection with one standard parallel (50°N) for a globe 5 inches in radius for an area extending from latitude 30°N, to 70°N, and for 60 degrees of longitude. Show meridians and parallels 10° apart. (*Punjab Univ., Inter., 1934 and 1939*)

9. What is Mercator's Projection ? In what maps of your Atlases is it usually employed ? Give its advantages and disadvantages.

What projection has been employed in the 1 to 1M sheets of the Survey of India that you have studied ? (*Punjab Univ., Inter., April 1941*)

10. What features distinguish the cylindrical from conical projections ? Give a graphic construction of the conical projection with one standard parallel.

(*Punjab Univ., Inter., 1943*)

11. What do you understand by the term "Map Projection"? What makes its study so necessary in geography ? How would you distinguish a net of simple Cylindrical Projection from one of Cylindrical Equal-area ? (*Punjab Univ., Inter., Sept. 1943*)

12. Describe and illustrate the Cylindrical Equal-area Projection. What advantages and disadvantages has it for map construction ? (*Punjab Univ., Inter., April 1946*)

13. Describe and illustrate a simple conical Projection with one standard parallel. State its advantages and disadvantages for map construction.

(*Punjab Univ., Inter., Supp. 1946*)

CHAPTER X

MAP PROJECTIONS—II

***90. The Globular Projection.**—This projection is much used in atlases for maps of the World in hemispheres, although it has no particular merits.

Construction of the Graticule. Describe a circle to scale to represent one hemisphere. Divide the equatorial diameter and the central meridian into 18 (or whatever number may be required) equal parts. Set off from the centre angles of 10° (or whatever angle may be required) and note where these cut the circumference. Draw circles through the Poles and the divions on the Equator ; these circles will represent the meridians. Draw curves through points on the circumference and the corresponding points on the central meridian. These curves will represent the parallels of latitude.

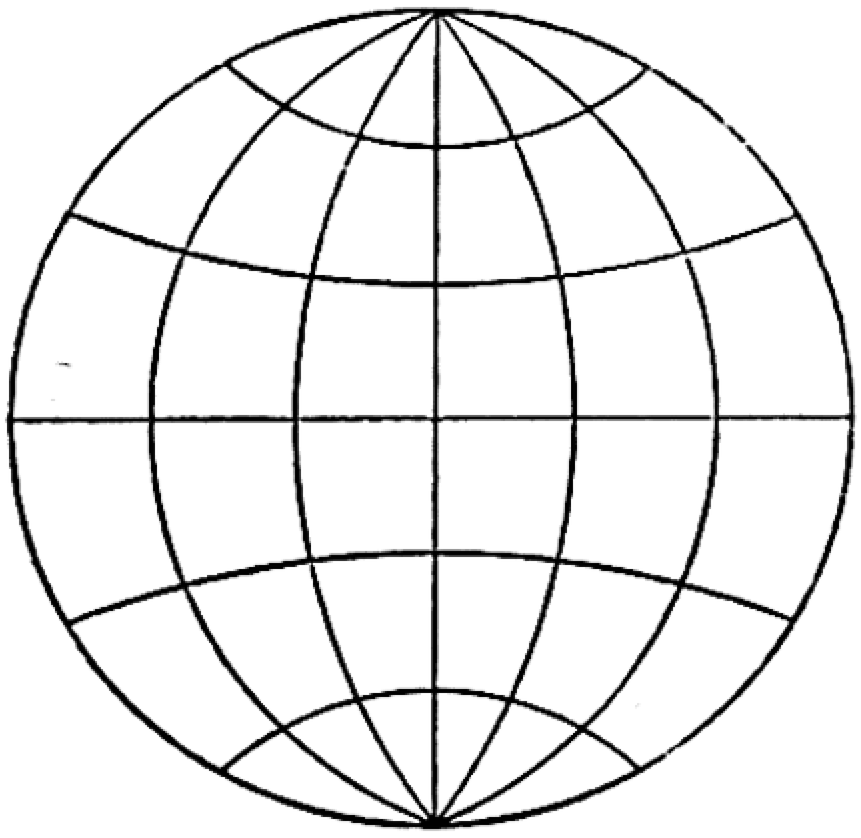


Fig. 44.

***91. Zenithal Projections.**—In these projections the net of parallels and meridians is drawn directly on a plane tangent to the globe at any point. Any great circle through this point will become a straight line through the centre of the map as if we cut the sphere and plane with a knife ; all such great circles will be represented by straight lines at true angles to each other. The direction of any point from the centre of the map is correctly given by a straight line joining the centre with the point ; hence these projections are also known as **azimuthal.** Usually the plane is tangent at one of the Poles (*Polar Case*), or the plane is tangent to the sphere at a point on the equator (*Normal Case*) or at any other point on the sphere (*Oblique Case*).

In Polar cases, one of the poles is the centre of the map net.

The following points may be noted :—

(*i*) The parallels will be projected as centric circles with the pole as the centre.

(*ii*) The meridians will be projected as straight lines radiating from the pole at their true angles.

The only difference between various forms of Polar Zenithal projections lies in the relation of the radii of concentric circles representing the parallels.

The construction of the net work of zenithals is very easily visualised if we take a transparent globe or projection apparatus (two wire hemispheres) and place it in various positions relative to a point of light (candle). The following cases arise :—

(*a*) If the light is at the centre of the sphere, we have the ***Gnomonic or Central Projection*** ; a useful Projection for navigation charts.

(*b*) If the light is at one end of the diameter *i.e.*, the other pole, it is called ***Stereographic Projection***. In other words, it is a perspective view of the globe from the opposite pole.

(*c*) If the light is at an infinite distance away *i.e.*, the rays of light are supposed to be parallel ; it is called *Orthographic Projection*. Every time we look at the moon, we get an orthographic projection of the moon.

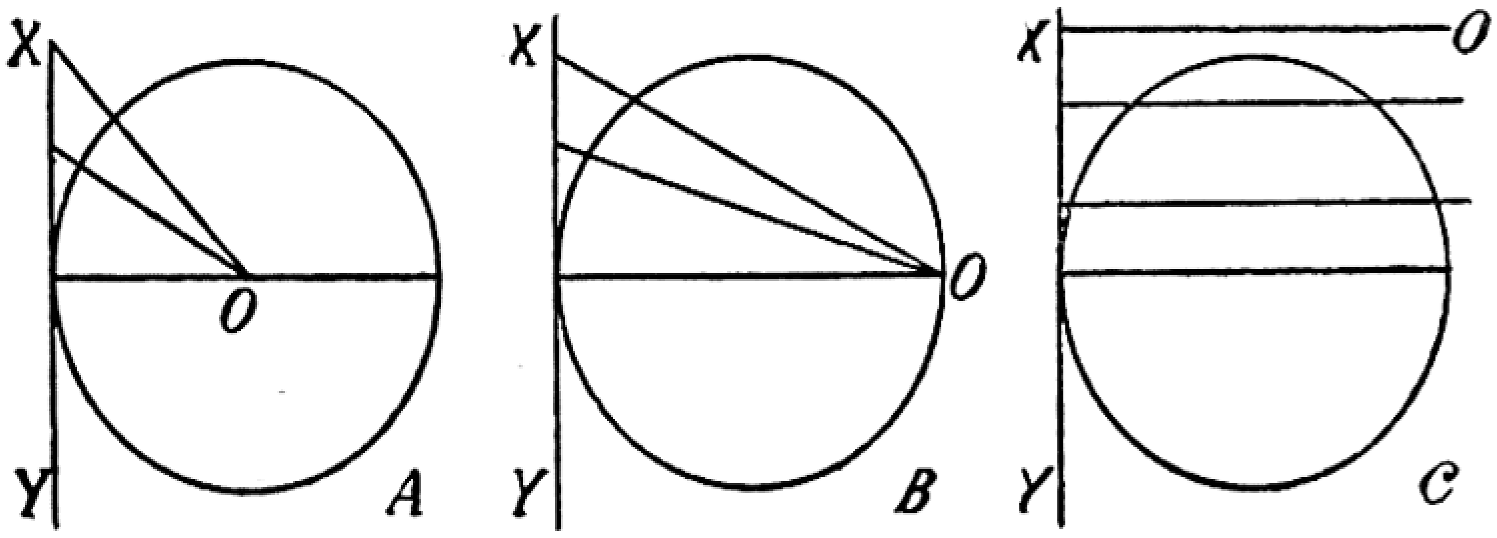


Fig. 45.

92. Equidistant Polar Zenithal Projection—The pole is taken as the centre of the map ; the meridians are drawn as radii from this point spaced at any desired angle. The parallels are concentric circles, are spaced at *equal* interval and are their true distances apart, hence the name *Equidistant.*

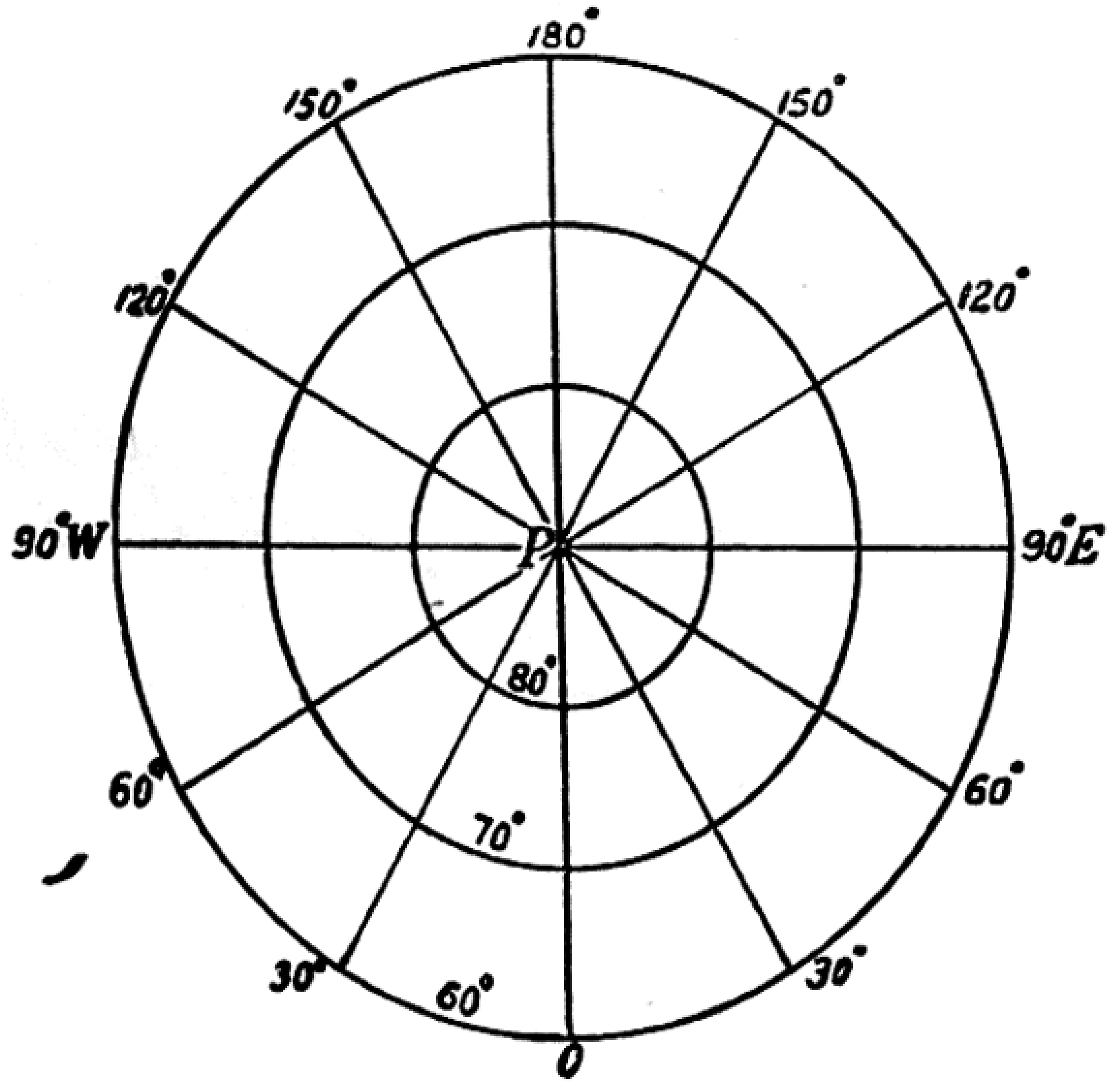


Fig. 46.

Construction.—It is required to draw a graticule on a scale of 1/125,000,000 with latitude interval of 10° and meridian interval of 30°.

Radius of the reduced earth on a scale 1/125M = 2 inches [See Section 80.]

$$\text{Circumference} = 2\pi r = 2 \times \frac{22}{7} \times 2 = 12{\cdot}56 \text{ inches}$$

The parallels are spaced at equal intervals

$$= 2\pi r \times \frac{d}{360}$$

where d is the required latitude interval.

∴ Distance apart of the parallels

$$= 2 \times \frac{22}{7} \times 2 \times \frac{10}{360} = 0{\cdot}349 = 0{\cdot}35 \text{ in. (approx)}$$

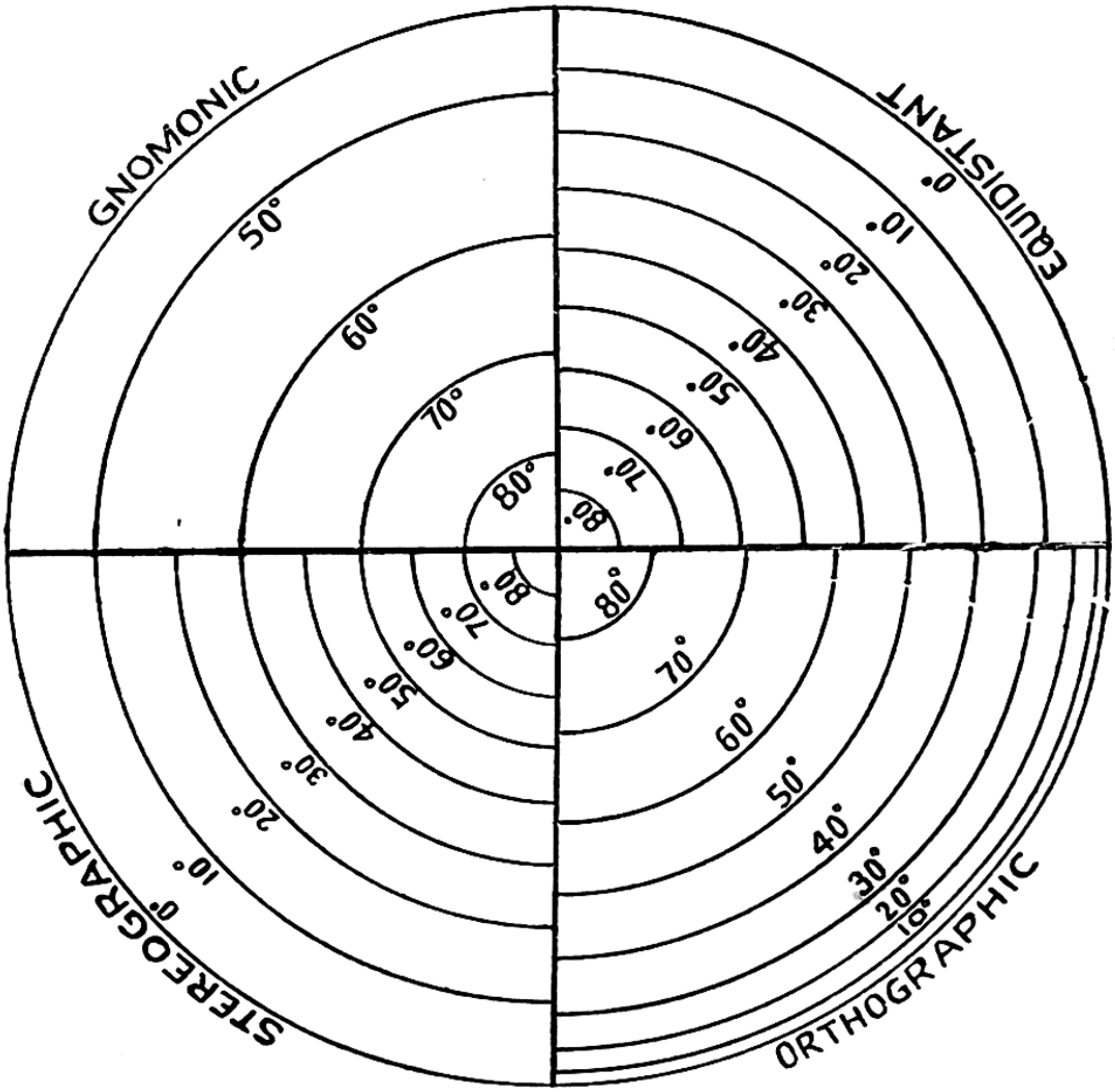


Fig. 47.

With P as centre and radius=2″ draw a circle. Draw the meridians by a protractor by laying off angles at intervals of 30°. Along the central meridian, beginning from P mark off divisions at intervals of 0·35 inches. With P as centre and these divisions as radii draw concentric circles. Mark these circles as 80°, 70°, 60°, etc

Merits, defects and uses.—(*i*) The bearing of any point from the pole is correct.

(*ii*) The distances from the pole to any point are correct. All distances along the meridians *i.e.*, distances measured from the pole will be true distances. The distances will be correctly represented, hence the name *Equidistant.*

(*iii*) The scale along the parallels is too great hence the parallels in proportion to the parallels on the globe will be too long. However for about 30° from the pole(*i.e.*, 60° to 90°), the projection is fairly good.

(*iv*) It keeps fairly accurately to shape (though not strictly orthomorphic) without any undue distortion of areas.

(*v*) It is used for maps of Polar Regions, the World in Hemispheres, and for regions north or south of the equator if the region is roughly circular or square in shape.

91. The Choice of a Projection.—The projection to be selected for any map depends upon two factors :—

1. The extent of the area to be represented, and
2. The purpose for which the map is mainly required.

The projection should fulfil both these considerations.

A few examples will make the matter clear.

Suppose a map is required to show the chief rice-producing areas of the world. We know that the chief rice-producing areas are in tropical and sub-tropical regions, hence the polar regions may be left out. Secondly we want to obtain at a glance an idea of the respective sizes of each area. Hence the best projection will be Cylindrical Equal-area, as the distortion of shape within 30° of the Equtaor is not too great.

Consider, again, a map to show the wheat-growing areas of the world. Equal-area Cylindrical Projection will not do for this purpose as the wheat growing areas are nearly all in temperate latitudes and in both hemispheres. The shape of the areas must be maintained as they are large areas. Hence Mollweide's projection will be best for this purpose. Should, however, an equal-area map of a country say the United States, showing the distribution of maize, be required, a Conical projection will be suitable for this purpose.

Other things being equal, a cylindrical projection is suitable for equatorial regions, a conical for temperate regions, and a zenithal for polar regions. For world maps Mercator's and Mollweide's projections are commonly employed. The Royal Air Force have adopted Mercator's projection for air maps ; in this and in showing main winds and ocean currents, *direction* is the most important criterion ; hence the use of Mercator's projection.

94. Identification of Projections.—The various projections can be identified with the help of the following table :—

1. *Parallels are straight lines*—

Meridians are straight lines spaced evenly and perpendicular to the Equator **and**

(*i*) Parallels are equidistant—**Simple Cylindrical.**

(*ii*) Parallels are close towards the poles—**Cylindrical Equal-area.**

(*iii*) Parallels are wider apart towards the poles—**Mercator.**

2. *Parallels are concentric circles*—

Meridians are radiating straight lines, **and**

Parallels are equidistant and are concentric circles—**Simple Conical or Equidistant-Polar zenithal.**

EXERCISES

1. Why is it necessary to study map projections ? Briefly describe the general classes of projections.

2. Write short notes on :—

Graticule, great circle, small circles, loxodrome.

3. Explain what is meant by a map projection. Compare the relative merits and defects of Mercator's and Mollweide's projections. (*Indian Police Service, 1930*)

4. What type of projection would be suitable for the following :—

(*a*) The distribution of cotton in the world.
(*b*) Political divisions of the world.
(*c*) Chief fisheries of the world.
(*d*) A general map of Sweden and Norway.
(*e*) A general map of India.
(*f*) The forests of Southern Continents.
(*g*) The distribution of tea in the Eastern Hemisphere ?

5. Construct a graticule for the Mercator projection taking the Equator as 12 inches.

6. Examine the following maps in the Oxford Atlas (Bartholomew) and decide which projection is used for each, giving reasons for your choice. Suggest alternative projections :—

(*a*) Africa. (*b*) Canada. (*c*) U.S.A. (*d*) Europe. (*e*) The British Isles. (*f*) India.

7. Construct a simple Conical graticule with one standard parallel on the scale of 1/100,000,000.

8. Describe any equal-area projection suitable for the whole Earth, and compare it with Mercator's projection (*a*) as regards construction of the net, and (*b*) as regards purposes for which it is suitable. (*Punjab, Univ., Inter., 1934*)

9. Name the principal advantages and defects of any two commonly used map projections. Describe simply the principle underlying any one of them.

(*St. Bede's Training Cert. Exam, 1934*)

10. Name any two projections suitable for the whole earth and compare them (*a*) as regards construction of the net, and (*b*) as regards geographical purposes for which each may be suitable. (*Panjab, Univ., Inter., 1935*)

11. Compare and contrast the Mercator's Projection with any equal-area projection for world maps, bringing out the advantages and disadvantages of each for geographical purposes. (*Panjab, Univ.. Inter , April 1939*)

12. What projections would you select for drawing maps of

(*a*) the lands round the Arctic Ocean.
(*b*) Africa showing equal-area.
(*c*) The prevailing winds and ocean-currents of the Atlantic Ocean ?

Give reasons for your choice in each case. (*Panjab, Univ., Inter , Sept., 1939*)

13. What is an equal-area Projection ? Is Mercator's Projection equal-area ? Give reasons.

What projection will you choose to show the political divisions of the world ?

(*Punjab., Univ., Inter., Sept., 1942*)

MISCELLANEOUS QUESTIONS

1. Write clear notes on the following with neatly drawn illustrations :—

    (*a*) Reduction of temperature to sea-level.
    (*b*) Isobars and Isotherms.
    (*c*) Distribution of population as shown by 'Dot method.'
    (*d*) Relative Humidity. (*Punjab., Univ., Inter.. Sept. '44*)

2. What are the important facts and how are they shown upon a daily weather chart issued in India ? What is the practical value of such a chart ? (*Punjab, Univ., Inter., Sept. '44*)

3. Define and illustrate an isotherm, a contour, an isopleth, a re-entrant, and barometric gradient. (*Punjab, Univ., Inter., April 1946*)

4. What is a 'cyclone' ? Briefly describe the weather associated with it and illustrate it as it would be on a weather chart. (*Punjab, Univ., Inter., April, 1946*)

5. In cycling through a village *A*, I ask my way to the village *B*, I get the following directions :—

"Go down the village street for ¼ of a mile, till you come to a mosque, which is on your left hand ; turn to the right, cross the bridge over the railway ; turn to the left, and then you follow the road running alongside the railway for two miles till you come to four cross-roads, in a wood, just after crossing a bridge over a stream. Turn to the right and keep to the road beside the stream for a mile ; you will see the village B nearly on your right."

Draw a sketch-map on a suitable scale which would help me to remember these directions.

6. Draw a section of railway line showing how double lines are distinguished from single lines and illustrating the symbols for cutting, embankment, level crossing, bridge under, bridge over, and station.

7. Make a list of the conventional signs classifying them under the heads :—

    (*a*) conventional pictures (*b*) colour patches (*c*) initials and (*d*) simple marks.

8. Classify the conventional signs used on one inch survey maps of India under the following heads :—

    (*a*) Relief features (*b*) Hydrographic features (*c*) Vegetation (*d*) Cultural.

9. What projection would you use for the following ? Give reasons for your choice :—

    (*a*) An air navigation map of Western Hemisphere.
    (*b*) A population map of the Panjab.
    (*c*) A general map of the three Southern Continents.

10. Construct a table of differences which you would use for the recognition by inspection of the projections you have studied.

11. Define the following terms in relation to map projection :—

    Graticule, rhumb line, great circle, arzimuthal, equidistant, orthomorphic, standard parallel, equal-area.

12. On an outline map of India indicate the changes that would take place if the sea-level rose 600 feet. Comment on the more striking of these changes and on any other important effects which would ensue.

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APPENDIX

APPARATUS

The following apparatus will be found necessary for the practical work described in this book :—

1. The Magnetic compass.
2. Prismatic compass.
3. Sundial.
4. Contour model.
5. Projection apparatus.
6. *Meteorological apparatus* :—
   Aneroid Barometer
   Fortin's Barometer
   Barograph
   Thermograph
   Maximum and minimum thermometers
   Wet and dry bulb thermometers
   Rain gauge

Maps etc. Survey sheets and Characteristic sheet of Conventional Signs may be had from The Map Record and Issue Office, Survey of India, Calcutta, Murree or Dehra Dun.

The Indian Daily Weather Report may be had from The Director-General, Meteorological Observatories, Poona.

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